A New Perspective for the Rationality of Fossil Fuel Divestment
- the Interaction between
the Shifting of Capital Flow and Stranded Assets

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

In recent years, fossil fuel divestment has shown increasing popularity among individual and institutional investors. Investors adopt this strategy due to two types of consideration, which are moral and financial concerns. Out of moral concerns, investors want to shift the capital flow to help limit the fossil fuel companies' business development and capital expansion, and out of financial concerns, investors want to avoid the financial risks coming from the stranded asset. However, the effectiveness of fossil fuel divestment as one of the climate actions is debated and challenged. The previous studies mainly focused on assessing the financial performance and carbon intensity of divestment or divest-reinvest portfolios to answer the question of "whether divestment can fulfill both financial and moral obligations", and these studies received mixed findings.

This study supports the rationality of fossil fuel divestment and reinvestment movements by supporting the two concepts, shifting of capital flow and stranded assets, which respectively relate to the moral and financial concerns. The direction of "causation" between these two concepts is also explored. The study focuses on the fossil fuel industry and the green energy industry, and the research sample selects 70 green energy companies from Nasdaq Clean Edge Green Energy Index (CELS) and 90 fossil fuel companies from Carbon Underground 200. Firstly, by applying the production theory and the Cobb-Douglas production function, two models are built with various factors of production or various financing methods with Ordinary Least Squares regression (OLS) on panel data of the two industries from 2013 - 2018. Secondly, the Granger Causation test is employed to explore the interaction between the various input factors of production and the industrial output, which supports the two concepts, shifting of capital flow and stranded asset. The interactions between these two concepts and the two concerns are also discussed. In addition, lagged OLS is employed to tackle the potential endogeneity issue in the regression model.

The findings of this study are in line with previous studies. The descriptive statistics show that the green energy industry can be a growing industry, while the fossil fuel industry can be a mature and probably, declining industry. The transition to a low-carbon

economy may accelerate this process. The regression identifies the factors which have significant influences on the output of the fossil fuel industry and the green energy industry. The Granger Causation test discovers the “bi-directional causality” (or “bi-directional feedback”) between the “market demand & industrial output” and the “various factors of production (model one) and various financing methods (model two)”, proving the two concepts of shifting of capital flow and stranded assets. Besides, the study explains the bi-directional interaction between these two concepts and finds that the shifting of capital flow precedes (contributes to, helps to predict) the stranded assets. At the same time, the stranded assets also precede (contributes to, helps to predict) the shifting of capital flow.

This study provides support to the rationality of carbon divestment from a new perspective. Compared to previous research, this study is not to explore the effectiveness of divestment from the perspective of market performance data, but to support the effectiveness by explaining the mechanism of this strategy. Besides the academic value, the models built in this study also have practical values. The two models, which are respectively built with various factors of production and various financing sources, are referable for the low-carbon economy transition and the development of responsible investment products.

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1. Introduction

Divestment is a socially motivated movement among private wealth owners to withhold their capital from companies related to business behaviors contributing to social and ecological harm by selling listed company stock, debt, and private equities (Ansar et al., 2013). Divestment has been applied in previous social movements such as the anti-apartheid boycott opposing the violations of human rights of the Apartheid system in South Africa from the 1960s to the 1990s. There are other examples, such as divesting from sin stocks (Fabozzi, & Oliphant, 2008; Hong & Kacperczyk, 2009) related to publicly traded companies producing alcohol, tobacco (Cogan, 2000; Wander & Malone, 2004), or are involved in gambling.

More recently, investing in fossil fuel companies has increasingly become controversial because the business activities of these companies contribute to the climate crises, and these companies are also spending money to curb climate actions and policies (Fossil Free, 2014, Supran & Oreskes, 2017). Fossil fuel divestment is one of the social and financial campaigns aiming to pressure fossil fuel companies to decrease the exploration of fossil fuel reserves and to force them to make transformative changes in their business activities. The divestment movement also puts pressure on governments to introduce legislation, such as banning future drilling and levying carbon taxes (Ansar et al., 2013). In addition to attracting the increasing attention of the press and media, a series of divestment-related events have attracted increasing awareness among stakeholders (Dordi & Weber, 2019). These stakeholders include individual and institutional investors, policymakers and campaign initiators, and financial institutions such as banks, insurance companies, security companies, and fund companies.

In recent years, investors, both individual and institutional, have shown a growing demand for socially responsible investment (SRI) portfolios. The US SIF Foundation (2018) calculated that in 2018, responsible investment increased more than 18 times compared to the amount in 1995, with a 13.6 percent compound annual growth rate. Asset managers manage $3,032 Billion for individual/retail investors and $8,601 Billion for institutional investors. Fossil fuel divestment is a subset of SRI and has also shown increasing popularity among institutional investors (Henriques & Sadorsky, 2018). Investors include universities (Linnenluecke et al., 2015), communities (McKibben, 2013), pension funds (Ansar et al., 2013), religious organizations, and charitable foundations (Howard, 2015; Milne, 2015; Usborne, 2014) in North America and European countries.

Investors choose to adopt fossil fuel divestment mainly due to two types of considerations: moral/ethical concerns and financial concerns. Divestment can be socially motivated and shows strong moral and ethical appeals. The fossil fuel divestment movement is also recognized as “norm entrepreneur” and “moral entrepreneur” (Fossil Free, 2014). Fossil Free, an organization that works on “a global movement to end the age of fossil fuels and build a world of community-led renewable energy for all” (Fossil Free, n.d.), believes that combating climate change should be a social norm. Because of moral concerns, investors, along with society, should take actions to address climate change.

The reasons are as follows. Fossil fuel burning is responsible for two-thirds of CO_2 emissions, making it one of the leading causes of climate change (Henriques & Sadorsky, 2018). The Intergovernmental Panel on Climate Change (IPCC) found that the consumption of fossil fuel reserves has to be limited to 20 percent or less (McGlade & Ekins, 2015; Meinshausen et al., 2009) to mitigate climate change. Since the business model of fossil fuel producers is a contradiction to this climate mitigation goal, some socially responsible investors chose to divest to limit these companies’ operation and capitalization capacity.

Financially, there are also incentives for fossil fuel divestment. According to Carbon Tracker Initiative (2011), to control the probability of temperature increase exceeding 2°C to 20 percent, the budget for CO2 emissions needs to be less than 565 Gt from 2010 to 2050. The climate emergency may lead to the announcement of more stringent climate policies for this the 2°C target, which could result in up to 80 percent of declared reserves related to the world's largest fossil fuel company becoming stranded assets. This means that the book value of these declared reserves will be significantly reduced. Both the fossil fuel industry and the investors who invested in this industry will have to face the malignant asset impairment.

However, the effectiveness of fossil fuel divestment as one of the climate actions is intensely debated and challenged. The doubts and criticisms can be summarized into the following points (Braungardt et al., 2019). Firstly, the nature of carbon emission makes both, fossil fuel producers and consumers, responsible for climate change. Policies driven by divestment do not take the consumers' moral responsibility into account, although fossil fuel consumption has a carbon footprint. Secondly, divestment has the potential to change the social norm, but so far, it is not accepted by the majority. It can be irrational to apply this subjective norm to each citizen in society. Consequently, the divestment decision of institutional investors can be overoptimistic on their beneficiaries' moral needs. Thirdly, since the capitalization of the fossil fuel industry in the world is massive, according to the present performance, divestment decisions among socially responsible investors are not likely to have a significant impact on the capital market as well as the fossil fuel industry. Hence, the effect of decreasing GHG emissions by divestment is questioned (Ansar et al., 2013).

Hereby, the research question is developed: Is there an interaction between the concepts of "shifting of capital flow" away from the fossil fuel industry and "stranded assets", which are the two concepts that justify the fossil fuel divestment strategy in the moral and financial perspective? The sub-questions are as follows. (a) Can we explain the respective market demand and output of products for the fossil fuel industry and the green energy industry with various factors of production or various financing methods? (b) What is the interaction between the "industrial output and demand" and "various factors of production and various financing methods", and which one is the preceding factor? (c) Can we explain the direction of causation between the concepts shifting of capital flow and stranded assets, and will this also help to explain the linkage between moral concern and financial concern in the divestment strategy of individual and institutional investors?

To answer these questions, 70 green energy companies from Nasdaq Clean Edge Green Energy Index (CELS) and 90 fossil fuel companies from Carbon Underground 200 are selected as the research sample. Based on this data, the study builds models based on the production theory with Ordinary Least Squares regression (OLS) on panel data of the fossil fuel industry and the green energy industry from 2013 - 2018. Two types of models with various factors of production and various financing methods for the two industries are constructed. Secondly, the interaction between the "market demand and industrial output" and the "various factors of production and various financing methods" is explored with the Granger Causation test, which also helps to explain the cause and effect relation between the two concepts shifting of capital flow and stranded assets. In addition, lagged OLS is employed to tackle the potential endogeneity issue in the regression model, which is a method employed in social science for causal identification on panel data (Bellemare et al., 2015).

The findings of this research are as follows. Firstly, the descriptive statistics show the changes in the quantity level of some industry indicators for the fossil fuel industry and the green energy industry, including the labor, the asset form of various production factors, the acquisition of various financing sources, and profitability. On the whole, the indicators of the fossil fuel industry show large fluctuations or a downward trend. In contrast, the indicators of the clean energy industry show a relatively stable and rising trend. According to these indicators, the study suggests that the green energy industry is a growing industry, while the fossil fuel industry is a mature and probably, declining industry. The transition to a low-carbon economy may accelerate the growth of green industries and the decline of the fossil fuel industry, making the differences in development patterns of the two industries more obvious.

Secondly, two regression analyses are used based on the production theory and the Cobb-Douglas production function. The independent variables in the first model represent the input factors in the form of assets, while the independent variables in the second model represent the financial sources of these input factors. The findings are as follows. This study identifies the factors which have significant influences on the output of the fossil fuel industry and the green energy industry. In model one, the factors such as Employees, Property & Plant & Equipment (PPE), and Cash & Equivalents have significant influences on the sales of both the fossil fuel industry and the green energy industry. Besides, the factor of Inventories is significant to the fossil fuel industry, and the factor of Intangible is significant to the green energy industry. In model two, all the factors are significant to the sales of both industries, including Employees, Long-term Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus), and Retained Earnings. The standardized coefficients also rank the significant factors according to the influence they have on the sales of the two industries. The R-squared (R^2) and the adjusted R-squared shows that these models have a better explanatory ability for the sales of fossil fuel companies (at around 0.9) compared to those of green energy companies (at around 0.6). The reason is that there can be omitted significant factors influencing the industrial output in the models for the green energy industry. For example, the external impacts, such as the support from the social and financial movements on low-carbon economy transition, may be one of the factors.

Furthermore, the study found that coal companies have a lower capacity of output (sales) with the same condition of financing sources compared to oil & gas companies. This study assumes that coal companies are relatively weak at the capacity of capital utilization, making these companies more vulnerable to changes in the accessibility to financial capital. This finding is in line with the finding that divestment announcements may have more impact on coal companies compared to oil and gas companies (Ansar et al., 2013). Finally, the year has a significant negative coefficient in the two models for the fossil fuel industry in 2015 and 2016. This finding matches the decrease in stock prices in the fossil fuel industry as well as the decrease in demand for fossil fuel products in these two years.

Thirdly, the Granger Causation test is employed to the fossil fuel industry, with the purpose of discovering the interaction between “the market demand & industrial output” and “the various factors of production (model one) and various financing methods (model two)”. A “bi-directional causality” (or “bi-directional feedback”) was found in this study, which supports the two concepts shifting of capital flow and stranded assets. This study also explores the bi-directional interaction between these two concepts and finds that the shifting of capital flow precedes the stranded assets. At the same time, the stranded assets also precede the shifting of capital flow.

The academic contributions of this study are providing support for the concepts of shifting of capital flow and stranded assets. They are corresponding to the motivations related to moral and financial concerns in the fossil fuel divestment strategy as well as other social and financial movements addressing the low-carbon economy transition. Previous studies mainly focused on assessing the financial performance and carbon intensity of divestment or divest-reinvest portfolios to answer the question of “whether divestment can fulfill both financial and moral obligations”. Since the positive influence of fossil fuel divestment is challenged and remains controversial, as mentioned above, this study provides support to the rationality of carbon divestment from a new perspective.

The outcomes of this study also have several practical values. On the one hand, the justified moral and financial concerns related to the carbon divestment strategy helps institutional investors to make invest-reinvest decisions. This study also supports policymakers and campaign initiators to curb the fossil fuel industry while supporting the green energy sector. On the other hand, since the first model is built with various input factors of production in the form of assets, and the second model is built with the acquisition of various financing sources, the regression coefficients of the two models have reference value for the low-carbon economy transition and the development of responsible investment products. The standardized coefficients suggest which factor of production has a great contribution to the output of the two industries. Besides, the regression coefficients for Contributed Capital and Long-term Debt, which respectively represent financing through equities and financing through debts, can help the investors to assess if their investment portfolios contribute more to the development of the green industry or the development of the fossil fuel industry.

The structure of this paper is as follows: the literature review section provides a detailed background of this study, followed by the methodology section with the introduction of the methods applied to this study. Then, the results of the analysis are presented. Finally, the discussion section concludes this study with findings, contributions, limitations, and outlook of future research.

2. Literature Review

This section starts with the introduction of some general concepts, such as sustainability and corporate social responsibility (CSR). Next, this section discusses the new moral and financial challenges, concerns, and obligations brought to the global financial sector coming from the demand for social and environmental sustainability and the transition to the low-carbon economy. Then, fossil fuel divestment, as one of the social and financial movements supporting the low-carbon economy transition, will be discussed. The pro-and-con arguments and goals of this divestment strategy will be explained. Finally, the theories employed in this study will be introduced. The details of the methodology of this study will be explained in the Methods section.

2.1. General Concepts: Sustainability and CSR

According to Brundtland (1987), sustainability is defined as developing without compromising the needs of future generations while meeting the needs of the present generation. Sustainable development considers the welfare of the present and future generations, which includes satisfying the present needs as well as safeguarding the Earth's life-support system to enable satisfying future needs (Griggs et al., 2013).

Corporate social responsibility (CSR) is a vehicle to achieve sustainable development (Moon, 2007; Weber et al., 2014), as CSR is the commitments and practices of companies to combine social and environmental sustainability with their main businesses. The concept of CSR "has had a long and diverse history in the literature" (Carroll, 1999, p. 291). In the evolution process of this concept, CSR emphasized different aspects: complying with policies related to social benefits in the 1950s (Bowen, 1953); fulfilling social responsibility to achieve long-term business success in the 1960s (Davis, 1967); balancing objectives within multiple interest groups and helping the society to achieve its basic goals in the 1970s (Johnson, 1971; Steiner, 1971); searching for opportunities from social problems for financial benefits and business success in the 1980s (Drucker, 1984); and, the combination of Stakeholder Theory, Business Ethics Theory, and Corporate Social Performance in the 1990s (Carroll, 1999). Carroll (1991) also framed this concept into the Pyramid of CSR, including economic, legal, ethical, and philanthropic responsibilities, which are the four types of CSR.

2.2. New Moral Concerns of the Financial Industry

This section will discuss the new moral concerns of the financial industry in the process of low-carbon economy transition. The transition requires the role-changing of the financial sector, bringing three aspects of moral considerations. These three aspects are: the sector has realized its ability and responsibility of influencing the financial capital flow; the existing and upcoming introduction of environmental regulations are expecting this sector to engage in combating the climate change; and, the stakeholders of this sector pressure the sector to consider the potential reputational consequences if a financial institution refuses to adopt this new moral obligation. Besides, the growing demand for the socially responsible investing (SRI) and the impact investing pushes the financial industry around the world to adjust their business and to meet the clients' requirements of both the good financial performance as well as the positive society and the environment influence.

2.2.1. The Role-changing of the Financial Industry

The financial industry has contributed to some controversial aspects. For example, narrow development, the opposite of "broad-based development" which enables to widely spread the benefits across society, becomes a major cause of conflict because such development cannot reduce poverty and exacerbates the initial inequality. The financial industry exacerbated the conflict, in the way such as intensifying high income-inequality and land-inequality between indigenous people and agrarian elites in agrarian society, enabling using state banking system for financing personal gain, and enabling the accumulation of wealth with fraud under weak financial regulation (Addison et al., 2001). Another example is high-leverage financial instruments, such as hedge funds, private equity-leveraged buyouts, high-leverage and subprime mortgage banking, and high-leverage banking de-coupled from the real economy and have contributed to global economic crises (Nielsen 2010). Besides, banks also provide financial support, such as loans to businesses or projects with highly negative impacts on the environment and society. These businesses include arm trade, pipelines, and big dams (Baranes, 2009).

The change of mindsets is needed for financial institutions. This change requires the financial industry to go back to its primary role: to serve the activities related to economy, trade, and human. For example, finance should not aim at short-term interests, or economic turmoils will occur, such as financial crises that took place in South-East Asia, Russia, Mexico, Argentina, and the United States sub-prime mortgages defaults (Baranes, 2009).

The financial industry has been making efforts to integrate sustainability into the business. Take banking as an example. Out of concerns related to risk, opportunities, and costs, banks integrated sustainability into their policies, strategies, products, services, and processes. Sustainability integrates into the new banking strategy and is recognized as a value driver, a public mission, and a requirement of clients (Weber 2005). For example, by applying the sustainability criteria to the credit rating process, banks can improve the predictive validity, showing an increase in correct risk classification and a decrease in wrong predictions (Weber et al., 2010). Another example is social finance, such as social banking, impact investment, and micro-finance. These new financing methods are with the purpose of achieving positive social impacts by investing or lending to companies that have positive social and environmental contributions. There is proof that social finance is contributing to both financial and social returns (Weber & Duan, 2012).

2.2.2. Implementation of Sustainable Development out of Moral Reasons

This section discusses three moral reasons that promote the financial industry to undertake growing moral obligations, which also encourage or pressure the role changing of this industry.

Firstly, the financial sector has the ability and responsibility of contributing to social and financial sustainability by influencing the financial capital flow to financed projects or borrowers in certain industries. Some projects, such as pipelines and big dams mentioned above, which are with highly negative environmental influences, requires substantial financial capital, making financial institutions being crucial in the process of construction (Baranes, 2009). Banks, as one of the financing sources and the lending institution for these projects, do not have direct pollution to the environment. However, the increasing belief is that the lending practices of banks which support projects with negative environmental impacts are responsible for such business activities (Sarokin & Schulkin, 1991; Gray & Bebbington. 2001). Current environmental regulations have already made banks liable for their borrowers' environmental damages, and banks gradually realize their roles and capacities in the financial capital allocation process. To minimize the risks of negative consequences coming from these environmental criteria, banks are integrating environmental concerns into the lending decision-making processes (Evangelinos & Nikolaou, 2009).

Secondly, the introduction of environmental regulations expects the financial sector to integrate environmental sustainability into the business. Here, two examples of climate finance and SRI movements are discussed. According to the definition of United Nations - Climate Change (n.d.), climate finance has the following characteristics: local, national or transnational financing; public, private, and alternative sources of financing; and, to support mitigation and adaptation actions for climate change issues. The efforts related to climate finance are in line with the Paris Agreement (as discussed later), which aims at shifting the financial capital flows to the development of low greenhouse gas emissions as well as climate-resilient. Therefore, there is a new responsibility for the financial sector to reallocate financial capital. It was estimated that to meet the goal of the Paris Agreement, the global renewable energy industry needs $1 trillion annually (Zuckerman et al. 2016), and the financial sector can be essential to engage in this process. Also, the financial industry's participation in combating climate change by climate finance is based on financial considerations, which will be discussed in the next section. The climate finance is an inside-out business strategy of the financial sector to tackle the regulation pressures, and Socially Responsible Investment (SRI) movements are the outside-in pressure that pushes the financial sector to make a change. The purpose of SRI movements is not limited to pressuring individual corporate polluters by methods such as fossil fuel divestment and shareholder activism. The SRI movements are promoting a framework that enables a more systemic change by promoting various investment codes of conduct. Some of these investment codes of conduct, such as the Climate Principles and the Carbon Disclosure Project, are for tackling climate change issues; and some of the codes, such as the United Nations Principles for Responsible Investment, are for propagating SRI in a general aspect (Richardson, 2009).

Thirdly, the pressure from stakeholders on social and environmental issues leads to the reputational risk of financial institutions. Brown and Whysall (2010) believe that reputation and trust are crucial to the finance and banking sector, and the financial institution is likely to rapidly become dysfunctional once the trust is weakened. Therefore, the maintenance of a good image of a financial institution relates to the interest of all this institution's stakeholders. Hoepner and Wilson (2012) conducted a structured literature review on the importance of Social, Environmental, Ethical, and Trust (SEET) issues on banks, and how these issues can influence the risk management, reputation and performance. As the concerns in social and environmental aspects (climate change in particular) have been growing rapidly in the banking sector, and the previous global financial crisis has already led to ethical and trust problems, the SEET issues in banking and other financial institutions require the efforts. Various international initiatives have been developed for the sustainability of the economy along with environment and society, including the UN Environmental Programme Finance Initiative, the UN Principles for Responsible Investment (PRI), and the Equator Principles.

To conclude, out of moral considerations, motivations, or pressure, the financial sector is gradually incorporating social and environmental sustainability into the business by adopting the new moral obligations in the new macro environment for this industry.

2.2.3. Socially Responsible Investing (SRI) and Impact Investing

Richardson (2008, p.130) summarized the various definitions of Socially Responsible Investing (SRI) based on the SRI associations' website, including definitions from the Association for Sustainable and Responsible Investment in Asia, European Social Investment Forum, Responsible Investment Association Australasia, UK Social Investment Forum, Canadian Social Investment Organization, and US Social Investment Forum. The Canadian Social Investment Organization defines SRI as, "the integration of environmental, social and governance (ESG) factors in the selection and management of investments", while the US Social Investment Forum define SRI as, "an investment process that considers the social and environmental consequences of investments, both positive and negative, within the context of rigorous financial analysis". Richardson (2008) pointed out that these definitions are boilerplate statements, being unclear, and could rationalize several market behaviors. This has the potential of leading to shallow marketing and green-washing, as well as to mislead socially responsible investors to believe that they have made positive impacts on the society with their investment methods.

Even so, Socially Responsible Investing (SRI), along with Impact Investing, is still recognized as an effective practice of combining social and environmental sustainability into finance and meets the moral demands of responsible investors. The reason is that both SRI and impact investing are incorporating non-financial factors, such as environmental and social factors, into investment analysis, with the mission of generating positive out-comings to society and the environment. There are differences between these two terms in two aspects. Firstly, screening methods are different. SRI applies negative screening, which is a passive strategy that avoids investing in companies and industries which violate ethical, environmental, or social criteria, and to make sure the investment portfolio does not bring negative influences on the society and environment. In comparison, impact investing applies positive screening, incorporating companies and industries that are generating positive social and environmental impact. Secondly, as to the expectation of financial returns, investors of SRI expect the maximization of financial return while achieving a positive influence on the society and environment. In contrast, the expectation of impact investors on financial return varies. Some of them require the maximization of financial performance, while others require the maximization of social and environmental impacts (Net Impact, n.d.). Therefore, it can be seen that SRI managers have more fiduciary obligations to fulfill for the investors compared to managers of impact investing.

Here is an example with regard to the fossil fuel industry and the clean energy industry. The fossil fuel industry can be considered as “immoral”, as fossil fuel burning is responsible for two-thirds of CO_2 emissions and is recognized as a major cause of climate change, while the clean energy industry is seen as “moral”, as the clean energy can be the alternative to traditional fossil energy with less pollution. The SRI screening process may remove the fossil fuel companies from a portfolio, while the impact investing screening process may add the green energy companies into a portfolio.

There is a growing demand for investment methods that contributes to social and environmental sustainability. Nowadays, clients want a desired impact along with their investments, pushing big financial companies around the world to take action to adjust their business and cater to this increasing demand (Kennedy, 2018, September 27).

Banks and asset managers are making efforts trying to meet the requirements from investors who want their investment to be both profitable and have a positive influence on society and the environment.

Financial institutions want to get involved in the big emerging market of impact investing. In addition to SRI methods, impact investing also tries to enable investors to achieve both positive financial returns as well as positive contributions to address social and environmental challenges (Bugg-Levine & Emerson, 2011). Michael Baldinger, head of sustainable and impact investing of UBS (UBS) Asset Management with 30 years of experience in the financial industry, pointed out that the impact investment has a $250 billion market (by the end of 2017), and it is growing fast. He said, “As an industry, we've had to rethink everything we do - impact and sustainability is the Silicon Valley of finance, and we want to be the Google.” Jackie VanderBrug, a managing director of U.S. Trust, Bank of America's (BAC), also pointed out that 76 percent of the millennial believes that their social, political and environmental values can be expressed with their investment decisions (Kennedy, 2018, September 27).

To conclude, the demand for sustainable development requires a change in the role of the financial industry. There is a business case for finance to be combined with social and financial sustainability. As stated above, the SRI and impact investing can be good methods to reallocate financial capital among industries with positive and negative screening methods, with the purpose of fulfilling both positive financial returns and positive social and environmental outcomes. However, due to the “boilerplate statements” of the SRI definitions among different peak SRI associations, the various investors’ expectations on financial and social/environmental returns, and the complexity of assessing the non-financial factors, there are risks while rationalizing different market behaviors, which may potentially lead to shallow marketing, green-washing, and other misleading business behaviors. To achieve effective finance interventions for complex sustainability problems, Wiek and Weber (2014) propose that financial sectors should first identify their roles related to sustainability problems and then develop intervention strategies to mitigate the issues identified. This brings the challenges of building casual links between finance and social/environmental concerns, as the prior condition of the effective intervention. Related to this study, the rationality of divestment and re-investment strategies will be supported by discovering the causal links between the two concepts, shifting of capital flow and stranded assets, which will be discussed later in this paper.

2.3. New Financial Concerns of the Financial Industry

Besides the moral concerns bring the new moral obligations to the financial industry, the transition to the low-carbon economy also challenging financial stability by bringing new threats and financial risks. This section discusses what challenges the low-carbon economy transition and upcoming environment or climate regulations will bring to the global financial sector. Also, some tools for managing these new financial risks will be introduced.

2.3.1. The Transition to Low-carbon Economy and the Financial Stability

The Paris Agreement is a landmark agreement for combating climate change issues among the 190 parties of the United Nations Framework Convention on Climate Change (UNFCCC) at COP 21 (or the Paris Climate Conference) on December 12, 2015. The Paris Agreement is the first universal, legally binding agreement on climate change issues, proposing a common cause to all nations in the form of countries' national commitments. The central aim is to mitigate the threat of climate change by limiting global warming, keeping the global temperature rise in this century well below 2 degrees Celsius compared to the pre-industrial levels, as well as pursuing efforts to limit the global temperature rise to 1.5 degrees Celsius. This agreement not only aims at claiming all nations make efforts to combat climate change but also to adapt to the impacts (United Nations, Climate Change, n.d.). Along with the high carbon intensity industries, the financial sector worldwide also confronts challenges in the adaption process.

Under such a circumstance, the financial sector from different nations is supposed to undertake new obligations, since the allocation of financial capital flows, as one of the functions of the financial sector, should be consistent with this global agreement. The financial sector should not only adjust the business to cater to the low GHG emission requirements (moral obligation) but also increase the resiliency to the potential negative impacts because of climate change (financial obligation). This increase in climate-resiliency is essential to the financial sector. Mark Carney, the governor of the Bank of England, warned that climate change risks could be the danger to the stability of the financial industry in some speeches and publications (Carney 2015). In this section, two types of threats related to climate change the financial sector has to confront are discussed, which justify the financial concerns of this sector. These two threats are "the low-carbon economic transition" and "the existing and upcoming environment/climate regulations".

The first concern is the pressure from the low-carbon economic transition. Taking Canada as an example, in response to the Paris Agreement, Canada has developed Mid-century and Long-term goals to achieve the GHG reduction. The transition to the decarbonization economy does not merely apply to the fossil fuel industry. There will be transitions in most of the Canadian industries. In this process, new pressures are placed on the financial industry. One of the pressure is that, as the high carbon intensity industries are pressured to reduce GHG emissions, additional expenses such as dealing with pollution and receiving fines occur. New regulations may also limit the production of high carbon emission industry, such as the fossil fuel industries. All these disadvantages negatively impact the profitability of these industries, which then exposes the investors and lenders of these industries to accumulating financial risks (Weber & Kholodova, 2017). Although it remains controversial whether the climate change risks will lead to the systematic risk, some systematic influences of climate change due to the transition to the low-carbon economy may occur in the form of rapid changing of companies' valuation and the depreciation of assets (Ansar et al., 2014; Carbontracker, 2015).

Besides, the existing and upcoming environment or climate regulations bring new challenges to the resiliency of the financial sector. Climate finance comes into existence as an essential part of the solution to tackle climate change from the financial industry. The financial sector is increasingly aware that climate change will transit into new kinds of financial risks, which can be a threat to investment portfolios but can also be an opportunity for increasing returns. A business case is created that investors should take action to tackle threats of climate change that come from the legal system which regulates greenhouse gases (Richardson, 2009).

Therefore, it is necessary for financial institutions to assess the threat that climate change risks will bring to their business and evaluate the potential losses they may encounter. The role changing of the financial industry requires new explorations of the high-resilient business models. Before constructing the new business model, there should be management tools enabling the identification and assessment of climate-related factors, which can be derived into climate-related risks or opportunities.

2.3.2. Tools for Managing New Financial Risks

The Task Force on Climate-related Financial Disclosures (TCFD), an organization that develops voluntary and consistent climate-related financial risk disclosures for companies, helps companies to provide better information to stakeholders such as investors, lenders, and insurers. TCFD also helps companies understand the expectations of disclosure from financial markets when it comes to climate-related risks (TCFD, n.d.). The financial impacts of climate-related risks are mainly in the following aspects: revenue, expenditure, assets & liabilities, and capital & financing. The TCFD creates a list of indicators helping the organizations in various sectors to identify the factors which have the most relevant financial impacts on their business (TCFD, 2017).

The identification of factors needs to be combined with scenario analysis. Wiek et al. (2006) pointed out that transition management related to sustainability management requires scenario construction. Therefore, the creating of climate change scenarios is required in the case of the low-carbon economy transition.

Here are the two examples of adopting TCFD indicators and the scenario analysis approach for climate-related risks management. The UN Environment Programme (UNEP) Finance Initiative (UNEPFI) initiated a year-long pilot project on implementing the TCFD recommendations. This project aimed to develop models and metrics for transition and physical assessment, which enables a scenario-based and forward-looking assessment and disclosure related to climate-related risks and opportunities. Sixteen leading global banks participated in this project and committed to publishing their first TCFD disclosure by mid-2019 (UNEP Finance Initiative 2019). Besides, Weber and Oyegunle (2019) conducted a MICMAC Analysis in combination with the scenario analysis approach. The MICMAC Analysis is a cross-impact matrix-multiplication method, enabling to explore the direct and indirect interrelational impacts of the various risk indicators proposed by TCFD. This study identified the most important factors while measuring the climate-related risk for the Canadian financial industry.

2.4. The Effectiveness of Fossil Fuel Divestment

The introduction section provided a brief overview of divestment and fossil fuel divestment. In this section, the debates on the effectiveness of applying divestment to mitigate climate change, which leads to opposite views, will be discussed. Braungardt et al. (2019) provide an overview of these arguments from public media and academic papers and organized these arguments into pro-and-con groups. In this paper, the influences of divestment are categorized into three categories: political, social, and economical. Out of these three aspects, this article will explain the mechanism of divestment while addressing climate change.

2.4.1. Influence on Policy

According to Fossil Free, an organization that works on “a global movement to end the age of fossil fuels and build a world of community-led renewable energy for all” (Fossil Free, n.d.), divestment is identified as a moral and political strategy instead of an economic one. Since fossil fuel divestment has a strong ethical driven factor, moral appeals among individual or institutional wealth owners can be a significant incentive to push forward climate actions and climate policies.

The presence of public support driven by moral concerns can promote climate action and lead to the implementation of climate policy. The enhancement of moral intuitions on climate change can encourage this process (Markowitz & Shariff, 2012). Grassroots activists are capable of attracting the attention of the media and arouse the concerns from the public, pushing the development of social norms. This bottom-up process can be the foundation that enables the top-down actions in the forms of international cooperation and coordination as well as international agreements (Gunningham, 2017).

Fossil fuel divestment also has the potential to stigmatize the fossil fuel companies and weaken the industry’s influence on policy. Brulle (2014) analyzes the funding dynamics and finds that some big fossil fuel companies are exploiting various activities to deny climate science as well as to curb the implementation of climate policies, such as lobbying, contributing to political candidates, and working with the media. For example, a case study investigates the Australian coal disclosure and highlights aggressive efforts during the engagement of the fossil fuel industry, which tries to sabotage the legitimacy of the divestment movement and discredit the campaigners and investors. These activities reflect that the industry is highly serious about this issue (Ayling, 2017). Therefore, the divestment strategy is capable of contending with the power of this industry and undermining the industry’s control over climate actions and policies.

However, although divestment can put pressure and limitations on the industry, we should also understand the systemic nature of carbon emissions. This systemic perspective links the producers and the consumers of fossil fuels, arguing that the fossil fuel industry should not take all the blame because of the consumers’ reliance on this industry’s product. MIT hosted a debate on the divestment strategy and Frank Wolak, a professor of economics at Stanford University, pointed out that the reason for the fossil fuel production is the demand for consumption: “It’s because we demand them, to heat our homes, to drive our cars, to fly in our airplanes.” “Divestiture does nothing to address that problem.” “As long as demand is still there for the fossil fuels, the greenhouse-gas emissions will exist, regardless of who owns the assets (MIT News, 2015)”

Based on this production-and-consumption nature, some divestment strategy opponents believe there can be more effective and efficient climate actions or policies which take the systemic nature into consideration. Some other strategies, including pricing the carbon emission with the carbon tax, carbon budget, and carbon trade, can also be effective, and even better, strategy to tackle climate change (Schifeling & Hoffman, 2019).

2.4.2. Influence on Social Norms

While fossil fuel divestment campaign is being driven by the moral concerns of socially responsible investors with the purpose of pressuring the industry and government to take positive action, this campaign is changing social norms and how citizens view the fossil fuels industry.

By engaging in the divestment campaign through litigation, fossil fuel divestment is turning into duty in investment decisions, especially for institutional investors. A widely mentioned case is a lawsuit filed by the student-organized Climate Justice Coalition alleging “mismanagement of charitable funds” and “intentional investment in abnormally dangerous activities” against the president as well as the fellows of Harvard College. The reason is that the school did not divest the endowment fund from fossil fuel companies (Braungardt et al., 2019; Franta, 2017; Richardson, 2017). Franta (2017) explores the potential of incorporating litigation into divestment campaigns in the future and points out the opportunity of developing standards of choice that helps to assign climate liability. There should not be excuses to keep investing in the fossil fuel industry because of a lack of choices, and financial returns should not be only the duty of public and charitable institutions.

Divestment campaigns also create opportunities to engage the young generation and educate them to become “lifelong climate activists”. Bratman et al. (2016) studies the fossil fuel divestment campaign among universities and argues that this campus movement has the potential to shift the expressed value from the economic value of the fossil fuel industry to an emerging paradigm of climate justice, which is mainly attribute to student activism. The review of press releases and news reports on student-led fossil fuel divestment in American higher education shows the positive impact of engaging youth on sustainable development. By aligning with sustainable culture and social justice, institutions of higher education can play a key role in the divestment campaign (Healy & Debski, 2017).

However, fossil fuel divestment has not reached a consensus globally, and it has not become a necessity to develop stringent climate actions and policies to tackle climate change. Awareness may not lead to real actions. Public support is not strong enough to make the implementation of climate actions and policies a necessity. Although the divestment campaign has the potential to impact the social norms, so far, it is still a subjective norm and may not apply to society as a whole. This brings to the question: why should a norm which is not supported by the majority of citizens be employed under the pressure of a sub-group in society without involving the democratic process? All citizens need to comply with it when this social norm is translated into concrete regulatory policies (Braungardt et al., 2019).

Firstly, this social norm brings challenges to institutional investors, such as university endowments and pension funds. Is it reasonable to divest while representing all the related individuals who have different attitudes on divestment or climate change? Bowen (2015. para. 3) is also not optimistic on the university divestment decisions by pointing out “taking an institutional stand on political issues of many kinds threatens the primary educational mission of the university, which is to be avowedly open to arguments of every kind and to avoid giving priority to partisan or other political viewpoints”.

Secondly, individuals may criticize the fossil fuel industry for being accountable to climate change and some institutional investors who do not divest. However, these people are not considering their responsibility in the divestment process, and one of the issues is that these people themselves are fossil fuel consumers or the beneficiary of the fossil fuel industry. Here are the questions. Will all beneficiaries or stakeholders of institutional investors accept the possible sub-optimal financial returns because of the reduced investment universe due to divestment? Will the students and faculties at a university accept the lack of funding to provide services or to support the research because of the financial losses caused by the divestment strategy? Therefore, the application of fossil fuel divestment probably has wider unfavorable effects and consequences which should not be ignored.

2.4.3. Influence on the Economy

The direct economic effect of divestment is to curb the fossil fuel industry’s capacity to increase exploration, production, and capitalization. Socially responsible investors choose to divest from this industry for two financial purposes: to depress the value of fossil fuel company stocks and to avoid the risks.

The first purpose is out of moral concerns, as the depreciation of these companies’ stocks has the potential to drive the industry to transition. Divestment announcements, such as campaigns, pledges, and endorsements, has the ability to impair the share price of this industry, thus showing that the divestment decisions of socially responsible investors have impacts on the divested fossil fuel companies (Dordi & Weber, 2019). Companies which are highly dependent on equity will be significantly influenced by stock price when the investors divest (Baker et al., 2003). Fossil fuel companies can be one of these types (Braungardt et al., 2019). An estimation in 2014 shows that there are 1,469 oil and gas companies trading on the stock exchange globally (Evans, 2014). Furthermore, Wolak (MIT News, 2015) pointed out that the fossil fuel industry has a total global capitalization of $60 trillion (at that time).

The second purpose is out of financial concerns, as the stringent climate policies in the future will limit the use of fossil fuels, and therefore depreciate the value of fossil fuel related assets. Since the investments related to fossil fuels decrease in value, these assets will become stranded assets and leading to a burst of trillion-dollar worth "carbon bubble", which has the potential of plunging the world into another economic crisis (Howard, 2015). According to an estimation in 2016 (Dietz et al., 2016), if following the "business as usual" strategy, the expected climate VaR (value at risk) for the global financial assets is 1.8 percent, which is equivalent to US$2.5 trillion, with a tail of 16.9 percent (US$24.2 trillion) at the 99th percentile. Another study in 2018 (Mercure, 2018) estimated the carbon bubble might lead to a global loss range of US$1–4 trillion, which is comparable to the 2008 financial crisis, if there is no climate action to tackle this issue. Therefore, to avoid the burst of carbon bubble, the decarbonizing process should be initiated as soon as possible.

A "divest-reinvest" strategy can also support low-carbon technologies and accelerate the transition process. While discussing the opportunity of renewables technology, economist Nicholas Stern believed that the most effective strategy is not limited to merely divestment from the fossil fuel industry. It is also recommended to invest in companies that are taking positive actions to tackle climate change (The Guardian, 2015). Divest-reinvest is described as an investment strategy which combines exclusionary decision with reinvestment (Hunt & Weber, 2019). This strategy aims at shifting the capital from carbon-intensive industries to positive climate solutions, such as developing renewables, which accelerates the transition to a green economy.

However, is there any proof that divestment is an optimal climate action with significant economic impacts on climate mitigation? Ansar et al. (2013) studied various institutional funds such as university endowments, public pension funds, and sovereign wealth management funds in different fund markets such as the US, UK, Canada, Australia, and the European Union. They found that the financial effect of divestment on GHG emission is limited. The reasons are as follows. Firstly, the capital that has the potential to be divested are low in quantity compared to the capitalization of fossil fuel companies, making the share prices of this industry less likely to be affected over the long term. It does not contradict the finding that divestment announcement can impair the share price (Dordi & Weber, 2019) since this finding is not applicable to assess long-term (more than ten days) effects. Secondly, investors who are motivated by financial benefits will replace socially responsible investors to hold divested shares. Oil and gas stocks are also among the best in liquidity. In comparison, coal stocks are less liquid. Divestment announcement may, therefore, have more impact on coal stock prices compared to oil and gas stocks.

2.4.4. Conclusion and Suggestion on Divestment

This section assessed the arguments on fossil fuel divestment and divided these views into three aspects, which relate to political, social, and economic concerns. It can be concluded that divestment, as effective climate action, faces the following challenges. (a) The systematic nature of carbon emission makes both fossil fuel producers and consumers responsible for climate change. Policies driven by divestment do not take into account the moral responsibility of consumers. (b) Divestment has the potential to change the social norms, but so far, it is not widely accepted. It can be irrational to apply this subjective norm to every citizen in society. The divestment decision of institutional investors can be overoptimistic on their beneficiaries' moral needs. (c) Since the capitalization of the fossil fuel industry in the world is massive, divestment decisions among socially responsible investors are not likely to have a significant impact on the capital market. The effect of decreasing GHG emissions by employing this investment strategy is also questioned.

Fossil fuel divestment is frequently compared with the anti-apartheid divestment movement in South Africa (Ansar et al., 2013; Braungardt et al., 2019; Hunt et al., 2017). This analogy may not be appropriate because of the massive global capitalization of the fossil fuel industry. As discussed, fossil fuel divestment has two types of reasons: ethical and financial. Therefore, the balance between the moral and financial concerns should be considered by both individual and institutional investors while developing the divestment strategies, especially the institutional investors as they are responsible for a group of beneficiaries' or stakeholders' interests.

Although sub-optimal financial returns can be acceptable to some socially responsible investors whose major purposes are to achieve the social-ethical goals (Renneboog et al., 2007), other investors may care more about the profitability. Bloomberg New Energy Finance (NEF) suggested that fossil fuel investment has four attributes, which are overall scale, liquidity, value growth, and dividend yield (Bullard, 2014). These advantages make fossil fuel investments favorable and become the imperatives of institutional investors. The representative role of these institutions makes the balance of moral and financial responsibility more essential, and sub-optimal financial performance may be, therefore, not acceptable. Braungardt et al. (2019) pointed out that if the divestment decision leads to financial loss and impacts the primary task of these institutions, additional ethical questions will be raised.

2.5. Identifying the Goals of Fossil Fuel Divestment

This section introduces three indicators to access the effectiveness of fossil fuel divestment, that is moral, financial, and industrial impacts. These three types of impacts are matched with three indicators, which are carbon intensity, financial return, and the aggregate-supply of the energy economy. Several previous studies focused on assessing the carbon intensity and financial return of the divestment strategy by comparing these two indicators between divested portfolios and conventional/benchmark portfolios. These studies received mixed results. In this study, a new indicator, which is industrial impacts, is introduced to the assessment. This new indicator is based on Cobb–Douglas production function. It is related to the "real economic factors" that will affect the aggregate supply/production of the industry, which are the fossil fuel industry and the green energy industry in this case.

2.5.1. Moral Responsibility: Carbon Footprint

Wackernagel and Rees (1997) applied the concept of the ecological footprint as a biophysical measurement while investing in natural capital to compensate for the net loss of this capital. The concept of carbon footprint can also be applied to assess the carbon intensity of investment. For example, according to the European emission trading scheme, carbon footprint helps to disclose the annual equivalent carbon emission output of a company, which enables investors to evaluate the carbon intensity of their investments (Hunt and Weber, 2019).

Socially responsible investors adopt the fossil fuel divestment strategy because the business model of fossil fuel companies contradicts with the objective of mitigating climate emergency, and they believe that withholding the capital of these companies is a good measure to fulfill the moral responsibility. Since the main purpose of divestment is to decrease carbon emission to tackle climate change, it is necessary to assess whether divested portfolios show significant decreases in the carbon intensity.

2.5.2. Financial Responsibility: Risk-adjusted Return

The risk-adjusted return is the criteria while comparing the financial performance of socially responsible investment (SRI) portfolios with the conventional ones. These SRI portfolios are designed with the criteria of environmental, social, and governance (ESG), including community involvement, corporate governance, diversity, employee relations, natural environment, human rights, and product quality (Henriques & Sadorsky, 2018). Henriques & Sadorsky (2018) found that the risk-adjusted returns of socially responsible investments could out-perform or under-perform compared to benchmark/conventional portfolios, but the differences were not significant. However, reduced risks (or reduced volatility) could be found in theses socially responsible investments.

According to portfolio theory (Markowitz, 1952), because the fossil fuel divestment strategy requires excluding the investment in some carbon-intensive industry, the risk-adjusted return of this strategy is expected to be lower than the conventional investments due to the reduced investment universe. If there are no financial reasons to narrow the investible universe, the risk-adjusted return of divested portfolios is not likely to reach the conventional benchmark.

A reinvestment strategy can be combined with the reinvestment strategy to improve the investible universe while being in line with the moral consideration. This means selecting capital related to positive climate actions. Renewable and clean energy can be one of these positive alternatives. This divest-reinvest strategy helps to reallocate the financial capital, curbing the development of carbon-intensive industry and promoting the growth of green energy industry. It is suggested that SRI funds can effectively exclude companies with bad behaviors by applying social screening, which helps to improve these funds' financial performance (Barnett & Salomon, 2003). The application of Environmental, Social, and Governance (ESG) criteria during the divest-reinvest process can maintain the investment universe and, therefore, maintain the financial performance. Another study also finds that there is no showing of risk-adjusted out-performance among fossil fuel stocks, and these stocks provide limited contributions to diversification (Trinks et al., 2018).

2.5.3. Industrial Impact: Aggregate-supply of the Energy Economy and "Real Economic Factors"

According to the economic definition, aggregate supply is the total quantity of goods and services produced by an economy in a given time period. The shift of Short-run aggregate-supply curve (SRAS) and Long-run aggregate-supply curve (LRAS) are both attribute to the "real economic factors", which are labor, capital, natural resources, and technology. Divestment and reinvestment mainly influence the capital flow among different industries in society as a whole. In this study, the indicators for the industrial impact of the divestment campaign derives from these "real economic factors" which have the ability to influence the aggregate supply/output of an industry. Quantifying these indicators will provide a new perspective on how divestment and reinvestment strategy can curb the carbon-intensive industry while supporting the green one, which can be important in the process of the low-carbon economy transition.

2.6. Theories

This section introduces the Cobb-Douglas production function, as the models in the study are built based on this function. The study on the interaction between corporate social responsibility (CSR) and corporate financial performance (CFP) is also mentioned.

Since this study supports the concepts of shifting of capital flow and stranded assets by exploring the interaction between various factors of production and the industrial output of the fossil fuel industry as well as the green energy industry, the study on the interaction between CSR and CFP has the reference value. The details of the model building will be discussed in the Methods section.

2.6.1. Cobb-Douglas Production Function

The models in this study are based on the production function and the Cobb-Douglas production function. The production function comes in various forms, and this study employs the Cobb-Douglas production function, as this is the most popular one. Cobb and Douglas (1928) introduced their production function, which discovers the relation between the input factors and industrial output. The input factors include two types, which are labor and capital, and the output is the total production enabled by different types of input factors. This function was developed with the data of the U.S. manufacturing industry form 1899 to 1922 and was criticized for lack of credibility. However, this production function was widely used decades later by economists such as Paul Samuelson, Robert Solow, and Marc Nerlove (Douglas, 1976).

It is complex to select the suitable input factors of production. The standard form for the Cobb-Douglas production function identifies two factors, which are the labor input and capital input (as shown in Equation 2-1). The details of the production theory and the Cobb-Douglas production function will be discussed in the Methods section.

Equation 2-1 The Cobb-Douglas Production Function with Two Factors

$$Y = A*L^{\beta}*K^{\alpha}$$

2.6.2. The Interaction between CSR and CFP

This study explores the interaction between the concepts of shifting of capital flow and stranded assets. These are the two concepts that justify the divestment strategy, which respectively corresponds to the motivations of carbon divestment strategy in the aspects of moral and financial concerns, as discussed in previous sections. This study on the interaction between these two concepts refers to the study of the interaction between corporate social responsibility (CSR) and corporate financial performance (CFP). Waddock and Graves (1997) found that Corporate social performance (CSP) is positively associated with the corporate financial performance (CFP) in the previous and the future period, which supports the “slack resource” theory as well as the “good management” theory, respectively. Scholtens (2008) studies the interaction between financial and social performance with the methods of lagged OLS and Granger causation to discover the predominant direction of “causation” between financial performance and social performance. A bi-directional correlation between the CSR and CFP leads to the future research of exploring the potential factor which has uni-directional causation to the CSR and CFP, and the factor “institutional framework” was discovered.

3. Objectives, Research Questions, & Hypothesis

As discussed above, social and financial movements that aim at shifting the financial capital to curb the business development and capital expansion of the fossil fuel industry, such as fossil fuel divestment, have reasons out of moral and financial concerns. The paper also assessed the arguments in favour and against fossil fuel divestment, dividing these views into three categories: political, social, and economical. It can be concluded that divestment as an effective climate action has been challenged, although this action is theoretically reasonable. When it comes to the rationality of fossil fuel divestment, the previous studies have been focusing on comparing the financial performance and carbon intensity of divestment or divest-reinvest portfolios, as these two indicators are identified as the representatives of financial and moral concerns. However, few studies have covered the potential economic effects of divestment and reinvestment on the fossil fuel industry and the clean energy industry, and these two industries can be the two important roles in the social transition to a low-carbon economy.

In this study, the economic effect is explored with indicators such as the industrial output and various “real economic factors”. To study the economic effects of fossil fuel divestment and reinvestment on the fossil fuel industry and the clean energy industry, models are built based on theory of production and Cobb-Douglas production function. Another interesting aspect is the exploration of the interaction between “industrial output” and the “real economic factors”, referring to the study about the interaction between corporate social performance (CSP) and corporate financial performance (CFP) through lagged regression. The interaction between these two factors will help to support the two concepts, which are shifting of capital flow and stranded assets, and these two concepts support the rationality of divestment and reinvestment as well as other social and financial movements in relation to moral and financial concerns. This study provides a new perspective on the rationality and industrial effects of these social and financial movements/campaigns, which contributes to the curbing of the fossil fuel industry and the promoting of the green energy industry.

Besides, this study is based on the production theory and Cobb-Douglas production function. However, the production theory is conceptual, and the Cobb-Douglas production function mainly identifies two factors, which are “capital” and “labor”. This study not only tests and provides support to these theories but also identifies the significant factors applying the accessible financial data. The model/function built in this study has practical values on resource allocation and industrial transformation for the fossil fuel industry and the green energy industry.

3.1. Objectives

This study consists of two steps, consisting of several objectives.

The first step is to identify significant variables from various “real economic factors” which respectively correlate to the industrial output of the fossil fuel industry and the clean energy industry. The objectives of this step are as follows.

(a) To test the production theory and Cobb-Douglas production function.

(b) To select the significant factors to build up the model.

The next step is to study the interaction between the “industrial output” and the “real economic factors”. The objectives of this step are as follows.

(c) To discover the direction of “causation” between the “industrial output” and the “real economic factors” by lagged analysis.

(d) To proof the concepts of shifting of capital flow and/or stranded assets.

(e) To explore the direction of causality between these two concepts.

Based on theory of production, this study will develop two types of models. In the first model, the “real economic factors” are the input factors in the form of various assets, which represents the contribution of different types of assets to the industrial output. In the second model, the “real economic factors” are represented by various equities and debts, which represents the financing methods such as stocks and loans. These two types of models have the following practical values.

(f) To provide suggestions on the resource allocation for the two industries, which helps the further development of the green energy industry and the low-carbon transition of the fossil fuel industry.

(g) To help socially responsible investors, policymakers, and the financial industry aware the potential impacts of social and financial campaigns which aim at shifting the financial capital to curb the business development and the capital expansion of the fossil fuel industry, and then, to make better decisions on the divestment and reinvestment strategies.

To provide suggestions on the divestment and reinvestment standards by calculating the proportion of fossil fuel and clean energy industry in an investment portfolio, with the purpose of achieving greater support for the production of the clean energy industry than the support for the fossil fuel industry.

3.2. Research Question & Hypothesis

Based on the two steps of this study, the following research questions and hypotheses are developed.

Step one: to test the production theory and to build the model.

1. Can the fossil fuel industry's total output be explained by factors of production (real economic factors) in the form of various assets?

H_0: the **fossil fuel industry**'s total output can not be explained by factors of production in the form of various assets.

H_1: the **fossil fuel industry**'s total output can be explained by factors of production in the form of various assets.

2. Can the **green energy industry**'s total output be explained by factors of production in the form of various assets?

H_0: the **green energy industry**'s total output can not be explained by factors of production in the form of various assets.

H_1: the **green energy industry**'s total output can be explained by factors of production in the form of various assets.

3. Can the **fossil fuel industry**'s total output be explained by factors of production in the form of various financing methods?

H_0: the **fossil fuel industry**'s total output can not be explained by factors of production in the form of various financing methods.

H_1: the **fossil fuel industry**'s total output can be explained by factors of production in the form of various financing methods.

4. Can the **green energy industry**'s total output be explained by factors of production in the form of various financing methods?

H_0: the **green energy industry**'s total output can not be explained by factors of production in the form of various financing methods.

H_1: the **green energy industry**'s total output can be explained by factors of production in the form of various financing methods.

Step two: to explore the interaction between “industrial output” and “real economic factors” by lagged regression analysis.

5. What is the direction of causality between the concepts of shifting of capital flow and stranded assets?

H_0: The shifting of capital flow precedes (explains/predicts) stranded assets.

H_1: The stranded assets precede (explain/predict) shifting of capital flow.

4. Methods

This study is quantitative research. It is data-driven and will apply statistical analysis and interpretation methods. The purpose of this study is to test the hypothesis closely related to previous studies and theories. The postpositivism worldview will be applied to this study. By applying this worldview, this study will:

1. test the production theory and Cobb-Douglas production function employing companies from the fossil fuel industry and the green energy industry as the sample, and build models based on these theories;
2. support the concepts of shifting of capital flow and stranded assets, which supports the rationality of divestment and other social and financial movements on low-carbon economy transition;
3. explore the direction of causality between these two concepts by referring the study on the interaction between CFP and CSR.

The strategy of inquiry consists of:

(a) the data collecting process will employ the data from the database of annual financial reports;

(b) the data analysis will apply descriptive statistics and regression analysis such as ordinary least squares (OLS) and lagged OLS to panel data.

The interpretation of the findings will be based on statistics and is closely related to the Postpositivism worldview, as the results mainly enable to build the model and to test theory and concepts.

The steps of the methodology applied in this study are displayed as follows (shown in Figure 4-1), corresponding to the following headings in this chapter. The main purpose of this chapter is to disclose the rationales and methods of this study related to data collection, variables selection, and model development. Two types of effective models are developed in this process, and these two types of models enable the further exploring of concepts, which are shifting of capital flow and stranded assets, as well as the interaction between these two concepts.

Figure 4-1 Steps of Methodology

Step 1	Data - Universe & Time Period
Step 2	Data - Sources
Step 3	Data - Processing
Step 4	Variables - the “Real Economic Factors”
Step 5	Modeling - Two models based on the Production Theory

4.1. Step 1: Data - Universe & Time Period

This section introduces the selection of data, which is related to the universe and time period of this study. This study will employ the fundamental data of companies trading on the North American financial market. The time period starts in 2013 when the fossil fuel divestment movement starts to gain momentum and ends in 2018. The data for 2019 is not available while conducting this research.

4.1.1. Fundamental Data of Companies - North American Financial Market

The sample of this study consists of the companies trading on the North American financial market, including North American companies and some of the global companies. The reasons are as follows. This study is conducted in North America. The findings of this study can be more in line with the local Socioeconomic background, making it convenient for the subsequent processes of application, evaluation, and modification of the research findings. Many previous studies have selected North American as the sample object. However, there are not any established effective models to assess the industrial impact of social and financial low-carbon transition movements on the economy of the energy industry. Because the effectiveness of these movements, such as fossil fuel divestment, remains uncertain, these movements remain controversial. It can be necessary and imperative to support the concepts such as stranded assets and to justify the necessity of the shifting of capital flow, which are respectively related to the financial and moral reasons of fossil fuel divestment.

4.1.2. Time Period

From 2012, there is a rapid increase in the number of institutions that commit to fossil fuel divestment. This campaign has grown faster than any previous divestment movement, and the growing momentum has appeared since 2013 (Fossil Free, 2018). Therefore, this study collects company data starting in 2012, which is the starting point of the fossil fuel divestment commitment of institutional investors. As company data for 2019 has not been disclosed during the data collection process of this study, the time span of the collected data is 2012 - 2018. Since data processing requires average the value at the beginning and end of the year, the calculated data observations of this study start from 2013, which also matches the point in time when the fossil fuel divestment movement started to gain momentum.

4.2. Step 2: Data - Sources

This section introduces the sources of data. The sample for the clean energy industry comes from the NASDAQ Clean Edge Green Energy Index (CELS), and the sample for the fossil fuel industry comes from the Carbon Underground 200 (2017). The fundamental data of companies in the sample is acquired from Wharton Research Data Services (WRDS).

4.2.1. Nasdaq Clean Edge Green Energy Index (CELS)

The sample of green energy companies comes from the NASDAQ Clean Edge Green Energy Index (CELS). According to the description, this index tracks the performance of a set of companies in the clean energy industry. Clean Edge, as the pioneer of the clean-tech stock index, launched this index in 2006.

The eligibility of this index is limited to specific security types, including common stocks, ordinary shares, ADRs, shares of beneficial interest or limited partnership interests, and tracking stocks. The evaluation of the constituent list of green energy companies is semi-annually, conducted by the NASDAQ Clean Edge Index Committee. Eligibility criteria are employed to assess the market data of this list of clean energy companies through the end of February and August, and the changes (additions and deletions) are applied after the close of trading on the third Friday of each March and September.

The index securities are not reviewed merely in the semi-annually evaluation process. If the constituent security on longer meets the eligibility criteria, or for some other reasons and become ineligible, this security is removed and is not replaced by new security till the next semi-annually evaluation. Therefore, the number of constituent securities in the NASDAQ Clean Edge Index is not constant. Besides, the Clean Edge website provides the details of index components updated in March 2019. The history lists of index components are not disclosed. However, this website provides the historical changes of the index components, including the additions and removals in each history semi-annually re-evaluations, and can be traced back to 2011. Therefore, the history of index components lists is generated through back derivation by the researcher. The detailed sample processing method for green energy companies will be discussed in the next section (4.4 Step 3: Data - Scrubbing).

The eligibility criteria of the NASDAQ Clean Edge Index can be divided into two aspects.

(a) The companies (issuers) representing the constituent securities should be contributing to the green energy, classified into the following sub-sectors:

- Advanced Materials (nanotech, membranes, silicon, lithium, carbon capture and
- utilization, and other materials and processes that enable clean-energy technologies);
- Energy Intelligence (conservation, automated meter reading, energy management systems, smart grid, superconductors, power controls, etc.);
- Energy Storage & Conversion (advanced batteries, hybrid drivetrains, hydrogen, fuel cells for stationary, portable, and transportation applications, etc.); and
- Renewable Electricity Generation & Renewable Fuels (solar photovoltaics, concentrating solar, wind, geothermal, and ethanol, biodiesel, biofuel enabling enzymes, etc.)

(NASDAQ Clean Edge Green Energy Index^{SM} Methodology, n.d., p. 2)

(b) The securities itself has to meet the following conditions in the financial market.

- Be listed on The Nasdaq Stock Market® (Nasdaq®), the New York Stock Exchange, NYSE American, or the CBOE Exchange;
- Have a minimum market capitalization of $150 million;
- Have a minimum average daily trading volume of 100,000 shares;
- Have a minimum closing price of $1.00;
- The issuer of the security may not have entered into a definitive agreement or other arrangement which would likely result in the security no longer being Index eligible;
- May not be issued by an issuer currently in bankruptcy proceedings;
- May not be placed in a trading halt for two or more consecutive weeks; and
- The issuer of the security may not have annual financial statements with an audit opinion

(NASDAQ Clean Edge Green Energy Index℠ Methodology, n.d., p. 2)

4.2.2. Carbon Underground 200 (2017)

The sample of fossil fuel companies comes from Carbon Underground 200. Carbon Underground 200 provides the list of the ranking of coal and oil & gas companies in 2017, which is the latest list available while conducting this research. The Carbon Underground 200™, short as CU200, identifies and ranks the top 100 coal and the top 100 oil & gas global publicly-traded reserve companies (or holders). The ranking is based on the estimated carbon emission resulting from the reported fossil fuel reserves of these holders. The methodology of Carbon Underground 200™ adopts the "IPCC Revised 1996 Guidelines on National Greenhouse Gas Inventories", which requires several conversions between the reserve and the potential carbon emission.

To acquire the full list of Carbon Underground 200 (2017), the registration to Fossil Free Indexes is required, as Fossil Free Indexes compiles and maintains the Carbon

Underground 200. The full list is publicly available and free of charge, but it is free only for non-commercial purposes. A paid subscription is required for asset managers and consultants. The subscriber needs to agree with the terms and conditions of the FFI license agreement during the registration process.

4.2.3. The Linkage between the Two Indexes

Since 2018, Clean Edge (Nasdaq Clean Edge Green Energy Index) collaborated with FFI (Carbon Underground 200) along with Alpha Vee Solutions for the creation of the "Energy Transition Long-Short Strategy”. This strategy intends to long clean energy and to short reserve-owning fossil fuel companies, with the expectation that the value of fossil fuel companies will decrease in the future while the value of the clean energy sector will rise. The FFI recorded the financial performance of this Energy Transition Long-Short Equity Strategy and compared it with the financial performance S&P 500 and S&P 500 Energy index. The Energy Transition Long-Short Equity Strategy started to out-perform the other two benchmarks since 2015, proving this long-short strategy between the fossil fuel companies and clean energy companies is effective.

4.2.4. Fundamental Information

Wharton Research Data Services (WRDS), as the destination for many of the leading research databases, provides aggregated and standardized financial data with standard format. The data provided in this database covers a great variety of disciplines, including Accounting, Banking, Economics, Finance, Insurance, Marketing, and Statistics. The Wharton School of the University of Pennsylvania hosts this WRDS database and makes available to subscribers from many universities worldwide. Different institutions may have access to different data sets.

The data in WRDS are organized by vendors, such as Standard and Poor’s (S&P), CRSP, New York Stock Exchange, etc. This study requires the fundamental information of companies, such as financial statements, and Compustat can meet this demand. Compustat, a database under the brand of S&P Capital IQ, provides more than 500 company-level fundamentals. The data, which are primarily drawn from SEC filings, can date back to 1950 for North American product and 1979 for the Global product. The North American companies added to the database have filed the distinct 10K (annual report) or 10Q (quarterly report) with the U.S. Securities and Exchange Commission (SEC). Thus, the authenticity and accuracy of the data in this database can be guaranteed.

To have access to the fundamental information of companies, the identifier for each company is required. The ticker is the widely used identifiers for companies. However, tickers can be changed or reused by other companies. Also, one company can have several tickers. In comparison, CRSP Permno, which identifies securities, and Permco, which identifies companies, do not change even when the company changes its name or ticker. These two identifiers never reassign as well. Compustat GVKEY is also an identifier for a company, and this identifier is mapped to the most recent company name and ticker. This identifier does not change, as well. In this study, the ticker is the primary identifier for companies. The time period of this study helps to select which ticker matches best with the company included in the sample. CRSP Permno and Compustat GVKEY for each company are also collected, which helps to match company-level data in the Compustat database with security-level data in the CRSP database.

4.3. Step 3: Data - Processing

This section discusses the sample screening methods applied in this study for the green energy industry as well as the fossil fuel industry.

4.3.1. Organizing the Constituent - Green Energy Companies

The study requires a list of green energy companies for each year of the time period, and the NASDAQ Clean Edge Green Energy Index (CELS) is selected as the sample, which means that the constituent companies represented in this index are recognized as the representative of the green energy company of the year. However, since the constituent companies in this index change during the semi-annually evaluation every March and September, a sample processing method needs to be developed to decide the list of green energy companies for each year's sample.

The updates of additions and removals take place in every March and September. Therefore, the adjustments to constituent companies can be categorized into four types.

1. companies that will be removed in the next evaluation and have kept in this index for at least one year;
2. companies that are newly added and will keep in this index for at least one year;
3. companies that are newly added but will be removed in the next evaluation;
4. companies that are unknown when to be removed from the index, which means that these companies are likely to be removed at the non-evaluation date.

Based on these four types of adjustments, the following sample processing method is applied.

To be kept in the list of green energy companies for the sample of that year:

(a) companies that are newly added in March and stay in the next September evaluation;

(b) companies that are kept in March but are removed in the next September evaluation;

(c) companies that are kept in September but are removed in the next March evaluation.

To be removed from the list of green energy companies for the sample of the year:

(d) companies that are newly added in September and stay in the next March evaluation;

(e) companies that are newly added in March but are removed in the next September evaluation;

(f) companies that are newly added in September but are removed in the next March evaluation;

(g) companies that are unknown when to be removed from the index, which means that these companies are likely to be removed at the non-evaluation date.

The sample processing method can be simplified as: the constituent companies that are kept in the list of green energy companies of the year have to stay in the index for at least eight months of that year. This allows the sample of companies to be the suitable representatives of the green energy companies of the year. The composition of the sample of green energy companies is as follows (shown in Table 4-1).

Table 4-1 The Composition of the Sample of Green Energy Companies

Green Energy Companies - Company Name	
8Point3 Energy Partners	Littelfuse
Acuity Brands, Inc.	Livent Corporation
Advanced Energy	Maxwell Technologies, Inc.
Aixtron SE	NextEra Energy Partners, LP
Albemarle	Nio Inc.
Ameresco, Inc.	ON Semiconductor
American Superconductor	OPower
Amyris	Ormat Technologies, Inc.
Atlantica Yield	Pacific Ethanol
AVX Corporation	Pattern Energy Group, Inc.
Ballard Power Systems	Plug Power, Inc.
Bloom Energy Corporation	Power Integrations
Brookfield Renewable Partners	PowerSecure International, Inc.
Canadian Solar	Renesola Ltd.
Capstone Turbine Corporation	Renewable Energy Group
China Ming Yang Wind Power Group Limited	Revolution Lighting Technologies, Inc.
Clearway Energy, Inc.	Rubicon Technology, Inc.
Cree, Inc.	Saft Groupe SA (insurance)
DAQO New Energy	Silver Spring Networks, Inc.
EnerNOC, Inc.	SolarCity Corporation
EnerSys	SolarEdge Technologies, Inc.
Enphase Energy, Inc.	Solazyme, Inc.(TerraVia)
First Solar, Inc.	SQM
FuelCell Energy, Inc.	SunPower Corporation
Green Plains	Sunrun, Inc.
Hannon Armstrong	TerraForm Global, Inc.
Hexcel Corporation	TerraForm Power, Inc
Hydrogenics Corporation	Tesla, Inc.

Integrated Device Technology, Inc.	TPI Composites, Inc.
ITC Holdings Corp.	Trina Solar Limited
Itron, Inc.	Universal Display
IXYS Corporation	Veeco Instruments
JA Solar Holdings	Vicor Corporation
JinkoSolar	Vivint Solar, Inc.
Linear Technology Corporation	Yingli Green Energy Holding

4.3.2. Organizing the Constituent - Fossil Fuel Companies

The latest available Carbon Underground 200 list is the 2017 version, including the top 100 coal and the top 100 oil & gas global companies (holders) according to the reported reserves. The time period of this study is 2013 - 2018, and the lists of the annual ranking for each year in this time period are not available. However, this study assumes that the global ranking of reported reserves among these biggest global fossil fuel companies may not have significant changes during 2013 and 2018. Therefore, this study selects the component companies in the 2017 list of Carbon Underground 200 to represent the top global fossil fuel companies (holders) during the time period of this study.

As the list suggested, there are 200 global fossil fuel companies on the list. This study, however, selects the fossil fuel companies traded in the North American financial market, which is aligned with the data universe of this study. The composition of the sample of fossil fuel companies is as follows (shown in Table 4-2).

Table 4-2 The Composition of the Sample of Fossil Fuel Companies

Headquarter Location	Company Name	Headquarter Location	Company Name
United States	Allete	United States	Rhino Resource Partners
United States	Alliance Resource Partners	United States	Rice Energy
United States	American Energy	United States	SM Energy
United States	Anadarko Petroleum	United States	Southwestern Energy
United States	Antero Resources	United States	Westmoreland Coal
United States	Apache Corporation	United States	Whiting Petroleum
United States	Arch Coal	United States	WPX Energy
United States	Black Hills	United Kingdom	Anglo American

United States	Cabot Oil & Gas	United Kingdom	BP
United States	California Resources	United Kingdom	Rio Tinto
United States	Chesapeake Energy	The Grand Duchy of Luxembourg	ArcelorMittal
United States	Chevron	Spain	Repsol
United States	Cimarex Energy	South Africa	Sasol
United States	Cloud Peak Energy	Russia	Gazprom
United States	Concho Resources	Russia	Mechel
United States	ConocoPhillips	Nigeria	Oando
United States	CONSOL Energy	Netherlands	Royal Dutch Shell
United States	Continental Resources	Italy	ENI
United States	Denbury Resources	India	Vedanta
United States	Devon Energy	Germany	BASF
United States	Energen	France	ENGIE
United States	EOG Resources	France	Total
United States	EP Energy	Colombia	Ecopetrol
United States	EQT	China	CNOOC
United States	ExxonMobil	China	PetroChina
United States	FirstEnergy	China	Yanzhou Coal Mining
United States	Foresight Energy	Canada	ARC Resources
United States	Gulfport Energy	Canada	Birchcliff Energy
United States	Hallador Energy	Canada	Canadian Natural Resources
United States	Hess	Canada	Cenovus Energy
United States	Linn Energy	Canada	Crescent Point Energy
United States	Marathon Oil	Canada	Encana
United States	Murphy Oil	Canada	Husky Energy
United States	NACCO Industries	Canada	Imperial Oil
United States	National Fuel Gas	Canada	Lundin
United States	Newfield Exploration	Canada	MEG Energy
United States	Noble Energy	Canada	Painted Pony Petroleum
United States	Oasis Petroleum	Canada	Peyto E&D
United States	Occidental	Canada	Seven Generations Energy
United States	PDC Energy	Canada	Suncor Energy
United States	Peabody Energy	Canada	Teck Resources
United States	Pioneer Natural Resources	Canada	Tourmaline Oil
United States	QEP Resources	Brazil	Vale
United States	Ramaco Resources	Australia	BHP Billiton
United States	Range Resources	Australia	Santos

4.4. Step 4: Variables - the “Real Economic Factors”

The model is built based on theory of production, consisting of input factors of production and industrial output. To quantify these factors as variables, the book values, which are disclosed in the company financial statements, are selected in this study. This study investigates the following variables by identifying these variables as the “real economic factors” which contribute to the output of production. The simplified Cobb-Douglas production function identifies two factors, which are the labor input and capital input. However, the input factors of production can be various. This study identifies the following input factors which may have significant contributions to the industrial output.

1. Employees

Number of employees (by year).

2. Property / plant / equipment (PPE)

According to IFRS (n.d.), IAS 16 establishes principles for the recolonization of property, plant, and equipment (PPE) as assets and “measuring their carrying amounts, and measuring the depreciation charges and impairment losses to be recognized in relation to them”.

Features:

- Property, plant, and equipment (PPE), also named as fixed assets, are the physical assets of a company that cannot be easily liquidated.
- PPE are long-term assets that are essential to business operations and the company’s long-term financial health.
- The purchases of PPE shows that the management of the company believes in a positive long-term outlook and profitability.
- Gross PPE is calculated by adding the amount of gross property, plant, and equipment, which are listed on the balance sheet, along with the capital expenditures. To calculate the net PPE, accumulated depreciation is subtracted.

- Net PPE = Gross PPE + Capital Expenditures − AD, where AD = Accumulated depreciation

3. Intangibles

According to IFRS (n.d.), IAS 38 “sets out the criteria for recognizing and measuring intangible assets and requires disclosures about them”.

Features:

- Compared to PPE, intangible assets are not physical and tangible. This type of assets can be goodwill, brand recognition, or intellectual property, and in the form of patents, brands, trademarks, copyrights, customer lists, literary works, and broadcast rights.
- Intangible assets can be either indefinite (a brand name) or definite (legal agreement and contract).
- Companies can create or acquire intangible assets.
- Intangible assets created by the company itself do not appear on the balance sheet and do not have book value.
- Intangible assets appear on the balance sheet if they are acquired from other companies. Also, when a company is purchased, and the purchase price is above the book value of assets on the balance sheet. The purchasing company will then record the premium paid as the intangible asset on its balance sheet.

4. Inventories

According to IFRS (n.d.), IAS 2 “provides guidance for determining the cost of inventories and the subsequent recognition of the cost as an expense, including any write-down to net realisable value”. It also “provides guidance on the cost formulas that are used to assign costs to inventories”.

Features:

- Inventory on the balance sheet consists of goods that are ready to sell as well as the raw materials that are used to produce the good, which is mainly in three types: raw materials, work-in-progress, and finished goods.

- On the balance sheet, inventory is classified as a current asset.

5. Cash & equivalents

Features:

- Cash and cash equivalents are both current assets and are shown as the first item on the balance sheet, as these are the most liquid assets.
- Cash refers to the currency deposited in the corporate accounting department and managed by the cashier and also included money in banking accounts and checks. Cash generally refers to “money in hand”.
- Cash equivalents are the items that are similar to cash, including low-risk securities, such as U.S. government T-bills, bank CDs, bankers' acceptances, and corporate commercial paper.
- Cash & equivalents may indicate the health of a company by reflecting the short-term debt solvency.
- Cash & equivalents, along with stocks and bonds, makes up the “three main asset classes” in finance.

6. Long-term debt

Features:

- In contrast to short-term debt, long-term debt matures in more than one year.
- Long-term debt is a liability to the Issuer.
- Long-term debt liabilities are always analyzed by stakeholders and rating agencies for the solvency risk assessment.
- Long-term debt includes bonds, mortgages, bank loans, debentures, etc.

7. Preferred stock

Features:

- Compared to common stock, holders of preferred stock have a higher claim on distributions (e.g., dividends), but these holders usually have minimal voting rights in corporate governance.
- During the liquidation process, preferred stock holders have greater priority of claim on assets common stock holders but less compared to debt owners (such as creditors and bondholders).
- Preferred stock has characteristics of bonds (debt) and common stock (equity).

8. Common stock

Features:

- Common stock is a security that represents ownership in a corporation.
- In the liquidation process, common stock holders have the least priority of claim on assets compared to preferred stock holders and debt owners, which means that common stock holders can only get the remainders of company assets.

9. Capital surplus

Features:

- Capital surplus, also referred to as premium, is the excess of the sold price of the common stock compared to its par value.
- Capital surplus is interchangeable with retained earnings.

10. Retained earnings

Features:

- Retained earnings are the remaining profits (net income) after dividends are paid out to shareholders.
- The company management makes the decision on the amount divided into retained earnings and the amount distributed among shareholders. For example, growth-focused companies only pay fewer dividends and allocate all the profits to retained earnings for future expansion.

The data for these variables comes from the statement of financial position and income statement. The statement of financial position, also referred to as the balance sheet, is always described as the "snapshot" of the business financial situation, which means that the information on this statement focuses on the point-in-time financial situation at the end of a business period or fiscal year. In comparison, the income statement, also known as profit and loss statement, shows the profitability of a company over an accounting period. Therefore, when processing the data form the statement of financial position, data are measured by averaging the data at the beginning as well as the end of the period (as is shown as follows, Table 4-3). The data from the income statement are directly adopted (Table 4-4).

Table 4-3 Data Processing Method for the Statement of Financial Position

Variables	Unit	Data Processing Method
Employees	per person	
Property / plant / equipment (PPE)	$ in thousands	
Intangibles	$ in thousands	
Inventories	$ in thousands	
Cash & equivalents	$ in thousands	(Beginning of fiscal year
Long-term debt	$ in thousands	+ Ending of fiscal year) / 2
Preferred stock	$ in thousands	
Common stock	$ in thousands	
Capital surplus	$ in thousands	
Retained earnings	$ in thousands	

Table 4-4 Data Processing Method for the Income Statement

Variables	Unit	Data Processing Method
Sales	$ in thousands	Ending of fiscal year

Another issue of data processing is the logarithmic transition of variables. Due to the characteristics of the logarithm, the conversion of data for each variable applies the following methods. (a) Since 0 has no logarithmic form, the logarithm of 1 is 0. So when the observation value is 0, this value is replaced by ln1. (b) After taking the logarithm, values less than 1 turn into negative, and negative observation value does not make sense for each variable in this study. Also, the statements data provided in the database is accurate to three decimal places. Therefore, all data is expanded by a factor of 1,000. The variable of employee changes the unit from "people in thousands" to "per person". Other variables change from "dollars in millions" to "dollars in thousands". (c) Negative values cannot be logarithmic. However, some variables, such as capital surplus and retained earnings, can be negative. Therefore, the following processing is performed on the negative variables (Equation 4-1), ensuring that the logarithmic form after processing is still negative without affecting the relative size of the absolute value.

Equation 4-1 Processing Method when the Observation Value is Negative

Logarithmic transition of negative value =

Ln (take the negative value of the original value *1000)

4.5. Step 5: Modeling - Two Models Based on the Production Theory

This section introduces the two steps of building the model. The first step is to develop the optimal model that explains the production of the green energy industry and the fossil fuel industry. The second step is to support the two concepts of shifting of capital flow and stranded assets and to explore the direction of causality between these two concepts. Ordinary least squares (OLS) regression and lagged variable regression will be applied in this study.

4.5.1. Step One - To Develop the Optimal Model that Explains the Production

The economics identifies the production function as one of the key concepts of mainstream neoclassical theories (Gallaway & Shukla, 1974; Solow, 1956). As one of the essential focus on economics, the production function provides the relationship between the quantity of various inputs and the quantity of outputs, defining the contribution of various input factors to the output of goods and with the purpose of addressing the resource allocation efficiency.

The general functional form of the production function is presented in the following form (Equation 4-2), where Y represents the quantity of output and X_1, X_2, X_3, X_4,..., X_n represents the quantity of various inputs. Among various formulations of the production function, the simplest one is the linear function (Equation 4-3), which is unlikely to be applicable in real-world practice; the popular one is the Cobb-Douglas production function (Equation 4-4).

Equation 4-2 The General Functional Form of Production Function

$$Y = f(X_1, X_2, X_3, X_4, ..., X_n)$$

Equation 4-3 The Linear Function of Production Function

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + ... + a_nX_n$$

Equation 4-4 The Cobb-Douglas Production Function

$$Y = a_0 * X_1^{a1} * X_2^{a2} * X_3^{a3} * X_4^{a4} * ... * X_n^{an}$$

The selecting of the most suitable input factors of production is complex. The input factors which contribute to the industrial output can be a lot, as is presented in the function as X_1, X_2, X_3, X_4,..., X_n. The standard form for the Cobb-Douglas production function identifies two factors, which are the labor input and capital input. The simplified version of the Cobb-Douglas production function is as follows (Equation 4-5).

Equation 4-5 The Simplified Version of the Cobb-Douglas Production Function

$$Y = A*L^{\beta}*K^{\alpha}$$

Where:

- Y = total production, which is the value of the total output.
- L = labor input, which is the total number of human workers working for the production.
- K = capital input, which is the tangible assets for the production process., including buildings, machines, and other equipment.
- A = total factor productivity (TPF), which measures the output that can not be explained by the input factors. The change of TPF reflects the improvement of technology or efficiency.
- The Greek characters α and β are the output elasticities for the input factors. Output elasticity is the change in the output that attributes to changes in input factors. These values are constants and are determined by available technology or efficiency.
- There are also other factors, such as Land (P), which represents natural resources, raw materials, and energy sources (oil, gas, and coal), and Entrepreneurship (H), which reflects the quality of the business intelligence.

In the study, the formation of the production function adopted is the Cobb-Douglas production function. However, the input factors are not limited to labor input and the capital input, and two sets of input factors are employed to build the model. One set of input factors are in the form of various assets, including employees, property & plant & equipment (PPE), intangibles, inventories, and cash & equivalents. The other set of input factors are in the form of various financing methods, such as equities and liabilities, including long-term debt, contributed capital (preferred stock, common stock, capital surplus), and retained earnings. The functions of the two models (Model 4-1, Model 4-2) are as follows.

Model 4-1 Model One - The Production Function Built with Various Assets

$Y = f_1$(Employees, PPE, Intangible, Inventories, Cash & Equivalents)

$Y = A * \text{Employees}^{a1} * \text{PPE}^{a2} * \text{Intangible}^{a3} * \text{Inventories}^{a4} * \text{Cash \& Equivalents}^{a5}$

Model 4-2 Model Two - The Production Function Built with Various Financing Methods (Equity & Liabilities)

$Y = f_2$(Employees, Long-term Debt, Contributed Capital, Retained Earnings)

$Y = A * \text{Employees}^{a1} * \text{Long-term Debt}^{a2} * \text{Contributed Capital}^{a3} * \text{Retained Earnings}^{a4}$

To transform the model into the linear model, this study takes the logarithm of all variables (as discussed in section 4.5.2 Measuring Method). Therefore, the model is transformed from multiplying the exponential form of several variables into adding the logarithmic form of several variables, making it more applicable to linear regression. The processed models are as follows (Model 4-3, Model 4-4).

Model 4-3 The Linear Model Form - Model One

$LnY = Lna_0 + a_1*Ln(\text{Employees}) + a_2*Ln(\text{PPE}) + a_3*Ln(\text{Intangible}) + a_4*Ln(\text{Inventories}) + a_5*Ln(\text{Cash \& Equivalents})$

Model 4-4 The Linear Model Form - Model Two

$LnY = Lna_0 + a_1*Ln(\text{Employees}) + a_2*Ln(\text{Long-term Debt}) + a_3*Ln(\text{Contributed Capital}) + a_4*Ln(\text{Retained Earnings})$

After the model is transformed, the meaning of the parameters (regression coefficients) acquired from the linear regression analysis also changes. The regression coefficient represents the elasticity between the output and the input factors, which means that when the independent variable (input factors of production) changes by 1 percent, what percentage of the dependent variable (industrial output) is expected to change.

4.5.2. Step Two - To Study the Two Concepts of Shifting of Capital Flow and Stranded Assets

This study analyzes the two concepts of shifting of capital flow and stranded assets, which supports the rationality of social and financial movements on low-carbon economy transition (such as fossil fuel divestment). This study also manages to answer the question, “what is the interaction between these two concepts” “is shifting of capital flow precedes and contributes to stranded assets, or is this interaction in the opposite direction?” To answer the question, the Granger causality test (Granger, 1969) is applied in this study to analyze the direction of causality.

The Granger causality test introduced the concept of lagged value, which is the value of the same variable earlier than the current period. To explain, if the current period is t_n, then the lagged period is t_{n-i} (i: the time lagged). According to the basic idea of Granger's causality test, future events will not have a causal effect on the present and the past, but past events may have an impact on the present and the future. There are two variables y_t and x_t. If the purpose is to explore whether x has a casual effect on y, it can be done by calculating whether the lagged value of x can affect the current value of y. If, after controlling the lagged values of the y, the lagged value of x still shows significant explanatory power to y, we can prove the variable x “Granger Impact (Granger-cause)” the variable y. The model for Granger causality is as follows (Model 4-5).

Model 4-5 Model for Granger Causality Test

$$\mathrm{y}_t = \alpha + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{i=1}^{q} \gamma_i x_{t-i} + \varepsilon_t$$

$$x_t = \alpha + \sum_{i}^{p} \beta_i x_{t-i} + \sum_{i}^{q} \gamma_i y_{t-i} + \varepsilon_t$$

The standard Granger causality test includes both the lagged independent variables (x_{t-i})

as well as the lagged dependent variables (y_{t-i}) into the model. Besides, the previous studies usually employ three or five lag-period values into one model. The purpose of the Granger causality test is to obtain at least one lagged value of the variable which is significantly correlated with the current value of another variable, proving the variable which takes the lagged value being "Granger causal" for the variable which takes the present value.

Therefore, to simplify the model for Granger causality test, in this study, the model only employs the variable of one lag-period, which is "x_{t-1}" or "y_{t-1}". The reason is that the independent variables that need the Granger causality test are too many, which will make the Granger causality model overloaded with variables if applying the standard Granger causality model in this study. The simplified model for the Granger causality test is as follows (Model 4-6), where x is the "various input factors of production", and y is the "industrial output".

Model 4-6 The Simplified Granger Causality Test

Lagging the x value: $\mathrm{y}_t = \alpha + \beta_i x_{t-1} + \varepsilon_t$

Lagging the y value:: $\mathrm{y}_{t\text{-}1} = \alpha + \beta_i \mathrm{x}_t + \varepsilon_{\mathrm{t}}$

Brook (2002) points out that the "causality" mentioned here is not corresponding with the standard notions of causation. This means that the Granger Causality test tries to prove the correlation between the current value of a variable and the past values of another variable. The Granger-causality between two variables can not be interpreted as the changing of one variable "causes" the other variable to change. Therefore, if the Granger-causality is found between variables A and B, and A is Granger causal for B, in this study it will be interpreted as "A precedes B", "A contributes to B", and "A helps to predict B".

Finally, since the Granger causality test can be essentially the application of lagged regression analysis, the following sections will have alternate uses of the terms "lagged regression" and "Granger causality".

4.5.3. Multiple Linear Regression on Panel Data

The analysis of multiple linear regression on panel data includes the following process.

(a) Test the homogeneity of variance for the dependent variable.

(b) Find out the input factors of production that are significantly related to the output in each model through regression analysis, and rank the input factors (independent variables) with statistical significance according to how well these input factors contribute to the output (dependent variable).

(c) Assess how well the models built in this study can explain the output (dependent variable) with the input factors (independent variables).

(d) Compare the models between the fossil fuel industry and the clean energy industry. The following paragraphs will explain these processes.

First of all, the significance level in this study is set to be 0.05, as the 0.05 significance level is the most commonly employed in studies. Therefore, if the p-value (or Sig.) is higher than 0.05, the null hypothesis for the tests can not be rejected, and the independent variable (input factors) is insignificant to the dependent variable (industrial output) and should be excluded from the model.

Although the main purpose of this step is to build the model by regression and to test the hypotheses of this study, however, before the regression, it can be necessary to test the homogeneity of variance for the dependent variable. Levene's Test is employed in this study to test the equality of error variances for every model. The null hypothesis for this test is that the error variance of the dependent variable is equal across groups.

To measure how well the models in this study can explain the output (dependent variable) with the input factors of production (independent variables), the R-squared (R^2) and the adjusted R-squared is employed. R-squared (R^2), also known as the coefficient of determination, is the statistical measure that represents the proportion of the variance for a dependent variable that can be explained by independent and controlled variables in the regression model. However, as the variables in the model increase, R-squared only increases and does not decrease, although the additional variables may not contribute significantly to the model's explanatory power. Therefore, the adjusted R-squared, as the modified version of R-squared, is employed, which takes the number of predictors (independent and controlled variables) in the model into account. The adjusted R-squared increases only if the additional predictor improves the model more than what is expected by chance, and it decreases when this predictor improves the model by less than what is expected by chance. To simplify, the adjusted R-squared can be recognized as a “penalty” for the excessive variables in the model.

The t-statistic is usually employed to assess the significance of each independent variable, and F-test is applied to test whether a set of independent variables is significant as a whole, which means not all of the regression coefficients of these variables equal to zero. In this study, the F-test is applied to every independent variable, which tests whether the coefficient of each independent variable is not equal to zero. This can be another method to validate the significance of variables employed in the model.

In addition to calculating the coefficients (beta, β) to indicate the relationship between the predictor variable (various input factors in this case) and the response variable (industrial output), the standardized coefficient is also calculated by standardizing all variables for the regression analysis. Standardized coefficient, also known as beta coefficients or beta weights, can solve the issue of different units of measurement among variables, as the standardized coefficient indicates the changes of standard deviations between the response variable and predictor variables. The purpose of standardization is to rank independent variables according to the extent of the effects they have on the dependent variable in the regression model.

5. Results

This study involves a total of 70 green energy companies and 90 fossil fuel companies. These companies are grouped according to the time period (2013 - 2018), which composites into panel data. After removing the samples with missing values, there are 215 observations for green energy companies and 452 observations for fossil fuel companies. As the sample size is sufficient, the distribution of observations tends to fit the normal distribution.

5.1. Descriptive Statistics

As the first step of statistical analysis, the descriptive analysis provides an overview of the characteristics of the data set by measuring the frequency, central tendency, and dispersion. In this study, frequency is measured by count, central tendency is measured by mean and grouped median, and dispersion is measured by variance, standard deviation, and range (maximum & minimum value). The details of descriptive statistics are in the following table (Figure 5-1).

Figure 5-1 Descriptive Statistics for Each Variable

See Appendix A

This study mainly focuses on the central tendency of each variable and choose the grouped median to represent the quantity level of different variables instead of the mean value. The reasons are as follows. Although the mean is always chosen as the measurement for central tendency, it is only suitable for normally distributed data. In comparison, the median can also reflect the overall level of the sample, regardless of the distribution of this sample. Since this study includes ten variables with a period of six years, there is a total of sixty groups. If choosing the mean as the measurement to describe the sample level, the investigation is required about whether all the data of these sixty groups are normally distributed, and it can not be expected that all these groups fit the normal distribution. Therefore, the grouped median is selected to represent the quantity level of different variables. The changing of each variable's level during the study period (2013 - 2018) is shown in the line charts below (Figure 5-2).

Figure 5-2 Line Charts - Grouped Median of Each Variable from 2013 - 2018

See Appendix B

As shown in the description statistics:

1. The number of employees in fossil fuel companies is decreasing over time, while the number for green energy companies is increasing with more significant increases after 2016.

2. The reliant on PPE, that is property & plant & equipment, remains stable for both fossil fuel companies and green energy companies. Fossil fuel companies show relatively bigger fluctuation. Since the holding of PPE reflects the company management's perspective on future profitability and growth, the relative stable shows that the present production level of PPE is enough for the market demand and competition in both industries.

3. The acquisition of intangible assets in fossil fuel companies fluctuates between the years, but the intangibles are increasing since 2016. In comparison, there is a steady growth over the years in the clean energy companies. To mention, the intangible assets recorded on the balance sheets are those which are acquired outside the company, which are not created by the company itself. For example, the book value of intangible assets for the ExxonMobil, one of the largest publicly traded international oil and gas companies, remained unrecorded (zero) over the years. However, it is unlikely that such a big international company does not own intangible assets, and, instead, the intangible assets of this oil and gas company is more likely to be created by the company itself. The line chart for intangibles shown above only reflects the demand for intangible assets that are purchased outside the company, and the pattern shows that both industries increase their demand for purchased intangibles.

4. The annual inventory for fossil fuel companies drops, while the figure for the

clean energy industry increases. There is an advocate for “zero inventory”, which means companies keep the minimal, no or little, inventory in their storage. This innovative inventory management method requires the optimal match between the purchase of raw materials for the production of goods and the selling of goods in a just-in-time manner. However, it seems that this goal is unlikely to achieve for the present management style of these two industries.

5. The figure of cash and equivalents for the fossil fuel companies fluctuates but increases overall; the figure for the green energy companies shows a stable and slight increase.

6. The long term debt represents the holding of debts that matures in more than one year, including matures bonds, mortgages, bank loans, etc. Both industries show slight increases. The increase in the fossil fuel industry is relatively sharper from 2013 to 2015.

7. The contributed capital consists of preferred stocks, common stocks, and capital surpluses, which reflects the scale of companies’ financing by issuing shares. The figure for the fossil fuel companies significantly increases compared to the figure for clean energy companies, which remains stable over the years.

8. The retained earnings present the remaining profits (net income) after paying dividends to shareholders. The overall level of retained earnings for the fossil fuel industry shows a significant downward trend. The figure for the clean energy industry starts to turn from negative to positive since bottoms out in 2016 and increases significantly in 2018.

9. The sales of the fossil fuel industry show a large fluctuation over time with no significant pattern of increase or decrease. In comparison, the sales of the clean energy companies also fluctuate but with a smaller scale and show an increasing pattern.

10. The net gain/loss of the fossil fuel industry also fluctuates substantially over the years, while the figure for the clean energy industry steadily increases.

To summarize, the changing of each variable are as follows. As for the labor, the number of employees for the fossil fuel industry was decreasing while the number for the green energy industry was growing. As for the various production factors in the form of assets, the holding for the fossil fuel industry fluctuated while the holding for the green energy industry was rising steadily. As for the various financing methods, both industries did not show an increasing demand for debts. However, the fossil fuel industry increased the financing through stocks, and the increase was more significant compared to the increase of the green energy industry. As for the profitability, both the sales and the net income fluctuated with a big scale in the fossil fuel industry. The retained earning for the fossil fuel industry has been decreasing over the years. In comparison, these indicators also fluctuated in the green energy industry but with a much smaller scale and was showing an increasing pattern.

5.2. Regression - Building the Model Based on the Production Theory

This study conducts two types of regression: one is multiple linear regression, and the other one is lagged regression. This section will present the result of multiple linear regressions, with the purpose of investigating the contribution of various input production factors on the industrial output for the fossil fuel industry and the clean energy industry. This step matches the following objectives: to test the production theory and Cobb-Douglas production function; to select the significant factors to build up the model.

Two models are built in this study. One is closely based on theory of production, and the other one is derived from the first model. The first model is built with various production factors in the form of assets, including Employees, Property & Plant & Equipment (PPE), Intangibles, Inventories, and Cash & Equivalents. The other model is built with various financing methods, which are the financial sources of companies to exchange the various production factors (assets) in the first model, including Employees, Long-term

Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus), and Retained Earnings. In short, the independent variables in the first model represents the existence form of the input factors, while the independent variable in the second model represents the financial sources of these input factors.

5.2.1. Model One - Input Assets Model

In this section, models will be built for the green energy and then for the fossil fuel industry with various production factors in the form of assets, including Employees, Property & Plant & Equipment (PPE), Intangibles, Inventories, and Cash & Equivalents.

First, the function for green energy companies is analyzed. The first step is to test the homogeneity of variance for the dependent variable "Sales" of the green energy companies by Levene's Test of Equality of Error Variances. The results are shown in the following table (Figure 5-3). The p-value (Sig.) is 0.709, much higher than the significance level (0.05). Therefore, the null hypothesis of Levene's Test, which is the null hypothesis that the error variance of the dependent variable is equal across year groups, can not be rejected. The homogeneity of variance for the dependent variable "Sales" of the green energy companies is assumed, which is qualified for the next step of multiple linear regression.

Figure 5-3 OLS - Model One - Levene's Test of Equality of Error Variances - Green Energy Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Green Energy Companies			
F	df1	df2	Sig.
0.588	5	209	0.709
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + Employees + PPE + Intangibles + Inventories + Cash & Equivalents + Year			

The next step is the multiple linear regression on panel data (as shown in Figure 5-4). At the significance level of 0.05, the statistically significant variables include Employees, Property & Plant & Equipment (PPE), Intangibles, and Cash & Equivalents. The variable "Inventories" is excluded because the p-value (Sig.) is 0.943, which is much higher than the significance level (0.05). Based on the result, the model for green energy companies, which is built with the various production factors in the form of assets, is as follows (Equation 5-1).

Equation 5-1 Model One - Built with Various Production Factors in the Form of Assets - Green Energy Companies

$Y = f_1(\text{Employees, PPE, Intangible, Cash \& Equivalents})$

$Y = A * \text{Employees}^{a1} * \text{PPE}^{a2} * \text{Intangible}^{a3} * \text{Cash \& Equivalents}^{a5}$

$LnY = Lna_0 + a_1{*}Ln(\text{Employees}) + a_2{*}Ln(\text{PPE}) + a_3{*}Ln(\text{Intangible}) + a_5{*}Ln(\text{Cash \& Equivalents})$

The R-squared (R^2) and the adjusted R-squared of this model also prove the statistically significance of independent variables. The R-squared (R^2) is 0.685, and the adjusted R-squared is 0.669. The dependent variable "Sales" of the green energy companies can be relatively effectively explained by the independent variables selected in this model.

The F-test is applied to each independent variable in the model, testing whether the coefficient of each variable is not equal to zero. The results of F-statistic (Figure 5-5) show that, except for the variable "Inventories", the coefficient of all the other independent variables are not equal to zero, proving that these variables can explain the dependent variable "Sales" of the green energy companies.

Figure 5-4 OLS - Model One - Parameter Estimates - Green Energy Companies

Parameter Estimates						
Dependent Variable: Sales - Green Energy Companies						
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	Partial Eta Squared

					95% Confidence Interval		
					Lower Bound	Upper Bound	
Intercept	5.167	0.55	9.393	0	4.083	6.252	0.302
Employees	0.237	0.043	5.455	0	0.151	0.323	0.127
PPE	0.077	0.021	3.684	0	0.036	0.119	0.062
Intangibles	0.04	0.016	2.511	0.013	0.009	0.072	0.03
Inventories	0.001	0.019	0.072	0.943	-0.035	0.038	0
Cash & Equivalents	0.433	0.05	8.615	0	0.334	0.532	0.267
[Year=2013.0]	-0.172	0.185	-0.93	0.353	-0.537	0.193	0.004
[Year=2014.0]	-0.13	0.178	-0.73	0.466	-0.48	0.22	0.003
[Year=2015.0]	-0.075	0.179	-0.418	0.677	-0.428	0.279	0.001
[Year=2016.0]	-0.035	0.182	-0.192	0.848	-0.394	0.324	0
[Year=2017.0]	0.089	0.187	0.475	0.635	-0.28	0.458	0.001
[Year=2018.0]	0[a]	.	.	.	.	.	

a. This parameter is set to zero because it is redundant.

Figure 5-5 OLS - Model One - Tests of Between-Subjects Effects - Green Energy Companies

Tests of Between-Subjects Effects

Dependent Variable: Sales - Green Energy Companies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	257.513[a]	10	25.751	44.302	0	0.685
Intercept	55.265	1	55.265	95.076	0	0.318
Employees	17.296	1	17.296	29.756	0	0.127
PPE	7.889	1	7.889	13.572	0	0.062
Intangibles	3.666	1	3.666	6.307	0.013	0.03
Inventories	0.003	1	0.003	0.005	0.943	0
Cash & Equivalents	43.14	1	43.14	74.217	0	0.267
Year	1.405	5	0.281	0.483	0.788	0.012
Error	118.579	204	0.581			
Total	39237.049	215				
Corrected Total	376.092	214				

a. R Squared = .685 (Adjusted R Squared = .669)

The study also calculates the standardized coefficient by standardizing all variables, with the purpose of ranking the independent variables according to their effects on the dependent variable “Sales”. As shown in the following table (Figure 5-6), the factor which has the most effect is “Cash & Equivalents”, followed by Employees, Property & Plant & Equipment (PPE), and Intangibles.

Figure 5-6 OLS - Model One - Standardized Parameter Estimates - Green Energy Companies

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	0.076	0.096	0.787	0.432	-0.114	0.266	0.003
Employees (Z-score)	0.319	0.059	5.455	0	0.204	0.435	0.127
PPE (Z-score)	0.195	0.053	3.684	0	0.091	0.299	0.062
Intangibles (Z-score)	0.115	0.046	2.511	0.013	0.025	0.206	0.03
Inventories (Z-score)	0.004	0.055	0.072	0.943	-0.105	0.113	0
Cash & Equivalents (Z-score)	0.417	0.048	8.615	0	0.322	0.513	0.267
[Year=2013.0]	-0.129	0.139	-0.93	0.353	-0.402	0.144	0.004
[Year=2014.0]	-0.097	0.133	-0.73	0.466	-0.359	0.165	0.003
[Year=2015.0]	-0.056	0.134	-0.418	0.677	-0.321	0.209	0.001
[Year=2016.0]	-0.026	0.136	-0.192	0.848	-0.295	0.243	0
[Year=2017.0]	0.067	0.14	0.475	0.635	-0.21	0.343	0.001
[Year=2018.0]	0[a]	.	.	.	.	.	.

Parameter Estimates. Dependent Variable: Sales - Green Energy Companies (Z-score)

a. This parameter is set to zero because it is redundant.

Next, the function for fossil fuel companies is analyzed. The Levene's Test of Equality of Error Variances is applied to the dependent variable “Sales” of fossil fuel companies. The results are shown in the following table (Figure 5-7). The p-value (Sig.) is 0.555, which is higher than the significance level (0.05). The homogeneity of variance for the dependent variable “Sales” of the fossil fuel companies is assumed, which is qualified for the next step of multiple linear regression.

Figure 5-7 OLS - Model One - Levene's Test of Equality of Error Variances

- Fossil Fuel Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Fossil Fuel Companies			
F	df1	df2	Sig.
0.793	5	446	0.555
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + Employees + PPE + Intangibles + Inventories + Cash & Equivalents + Dummy Variable + Year			

Followed by the multiple linear regression (as shown in Figure 5-8), at the significance level of 0.05, the statistically significant variables include Employees, Property & Plant & Equipment (PPE), Inventories, and Cash & Equivalents. The variable "Intangibles" is excluded because the p-value (Sig.) is 0.588, which is higher than the significance level (0.05). Furthermore, a dummy variable is employed in this model. The value for coal companies is 1, and the value for oil & gas companies is 0. The p-value (Sig.) for this dummy variable is 0.537, showing that this dummy variable (coal = 1, oil & gas = 0) is not significant in this model, which means that there is no significant difference between the output (sales) of coal companies and oil & gas companies with same conditions of input factors. Besides, the intercept in this model is also insignificant, with the p-value of 0.418 (> 0.05). Therefore, the model for fossil fuel companies does not include an intercept. Based on the result, the model for fossil fuel companies, which is built with the various production factors in the form of assets, is as follows (Equation 5-2).

Equation 5-2 Model One - Built with Various Production Factors in the Form of Assets

- Fossil Fuel Companies

$Y = f_1(\text{Employees, PPE, Inventories, Cash \& Equivalents})$

$Y = A * \text{Employees}^{a1} * \text{PPE}^{a2} * \text{Inventories}^{a3} * \text{Cash \& Equivalents}^{a5}$

$LnY = Lna_0 + a_1 * Ln(\text{Employees}) + a_2 * Ln(\text{PPE}) + a_3 * Ln(\text{Inventories}) + a_5 * Ln(\text{Cash \& Equivalents})$

The R-squared (R^2) and the adjusted R-squared of the first model prove the statistically significance of independent variables. The R-squared (R^2) is 0.934, and the adjusted R-squared is 0.933. The dependent variable “Sales” of fossil fuel companies can be explained by the independent variables selected in this model.

The results of F-statistic (Figure 5-9) shows that, except the variable “Intangibles”, the coefficient of all the other independent variables are not equal to zero, proving that these variables can explain the dependent variable “Sales” and, therefore, can remain in the model.

Figure 5-8 OLS - Model One - Parameter Estimates - Fossil Fuel Companies

Parameter Estimates							
Dependent Variable: Sales - Fossil Fuel Companies							
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	-0.254	0.314	-0.81	0.418	-0.871	0.363	0.001
Employees	0.244	0.028	8.829	0	0.19	0.299	0.15
PPE	0.821	0.026	31.342	0	0.769	0.872	0.691
Intangibles	0.003	0.006	0.542	0.588	-0.008	0.014	0.001
Inventories	0.019	0.008	2.394	0.017	0.003	0.035	0.013
Cash & Equivalents	0.029	0.013	2.266	0.024	0.004	0.055	0.012
Coal=1; Oil & Gas=0	0.051	0.083	0.618	0.537	-0.112	0.215	0.001
[Year=2013.0]	-0.064	0.131	-0.489	0.625	-0.322	0.194	0.001
[Year=2014.0]	-0.002	0.095	-0.017	0.986	-0.188	0.185	0
[Year=2015.0]	-0.38	0.095	-3.989	0	-0.568	-0.193	0.035
[Year=2016.0]	-0.497	0.096	-5.182	0	-0.685	-0.308	0.058
[Year=2017.0]	-0.163	0.096	-1.699	0.09	-0.351	0.025	0.007
[Year=2018.0]	0[a]	.	.	.	.	.	.
a. This parameter is set to zero because it is redundant.							

Figure 5-9 OLS - Model One - Tests of Between-Subjects Effects - Fossil Fuel Companies

Tests of Between-Subjects Effects						
Dependent Variable: Sales - Fossil Fuel Companies						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2370.856[a]	11	215.532	569.194	0	0.934
Intercept	0.757	1	0.757	2	0.158	0.005
Employees	29.517	1	29.517	77.952	0	0.15
PPE	371.978	1	371.978	982.348	0	0.691
Intangibles	0.111	1	0.111	0.294	0.588	0.001
Inventories	2.17	1	2.17	5.729	0.017	0.013
Cash & Equivalents	1.945	1	1.945	5.135	0.024	0.012
Coal=1; Oil & Gas=0	0.145	1	0.145	0.382	0.537	0.001
Year	17.386	5	3.477	9.183	0	0.094
Error	166.611	440	0.379			
Total	109171.67	452				
Corrected Total	2537.467	451				
a. R Squared = .934 (Adjusted R Squared = .933)						

According to standardized coefficients calculated with standardized variables, as shown in the following table (Figure 5-10), the factor which has the most effect is "Employees", followed by Cash & Equivalents, Property & Plant & Equipment (PPE), and Inventories.

Figure 5-10 OLS - Model One - Standardized Parameter Estimates - Fossil Fuel Companies

Parameter Estimates							
Dependent Variable: Sales - Fossil Fuel Companies (Z-score)							
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	0.074	0.029	2.54	0.011	0.017	0.132	0.014
Employees (Z-score)	0.228	0.026	8.829	0	0.177	0.279	0.15
PPE (Z-score)	0.682	0.022	31.342	0	0.639	0.725	0.691
Intangibles (Z-score)	0.008	0.016	0.542	0.588	-0.022	0.039	0.001
Inventories (Z-score)	0.044	0.018	2.394	0.017	0.008	0.08	0.013
Cash & Equivalents	0.042	0.018	2.266	0.024	0.006	0.078	0.012

(Z-score)							
Coal=1; Oil & Gas=0	0.021	0.034	0.618	0.537	-0.046	0.088	0.001
[Year=2013.0]	-0.026	0.053	-0.489	0.625	-0.131	0.079	0.001
[Year=2014.0]	-0.001	0.039	-0.017	0.986	-0.077	0.075	0
[Year=2015.0]	-0.155	0.039	-3.989	0	-0.231	-0.079	0.035
[Year=2016.0]	-0.202	0.039	-5.182	0	-0.279	-0.126	0.058
[Year=2017.0]	-0.066	0.039	-1.699	0.09	-0.143	0.01	0.007
[Year=2018.0]	0[a]	.	.	.	.	.	

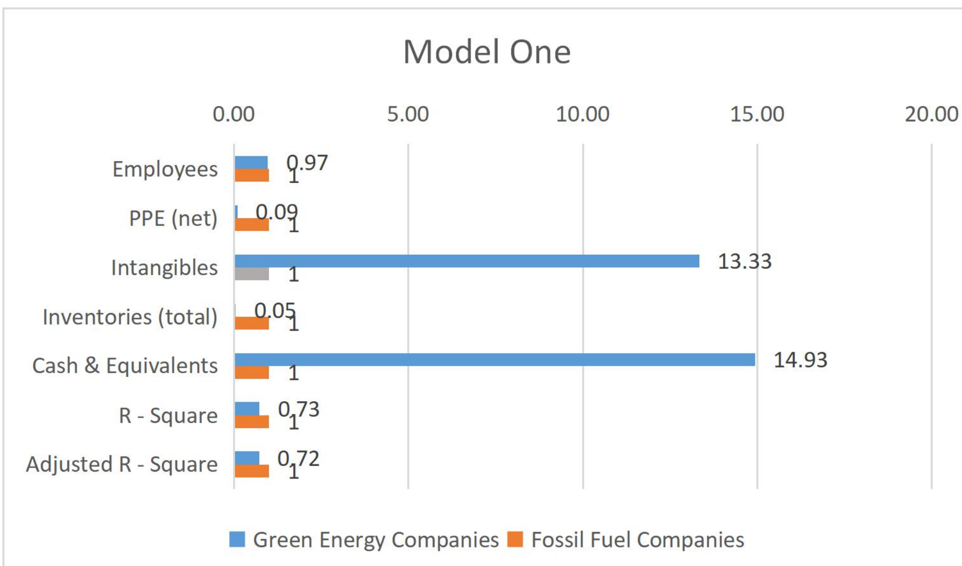
a. This parameter is set to zero because it is redundant.

The first models for green energy and fossil fuel companies are compared. Firstly, the significant input factors (independent variables) in the first model for green energy companies and fossil fuel companies are compared, as well as the ranking of which input factors (independent variables) have greater effects on the "sales" (dependent variable) between these two sample groups. For all the input factors, including Employees, Property & Plant & Equipment (PPE), Intangible, Inventories, and Cash & Equivalents, the factor "Inventories" is not significant for green energy companies, while the factor "Intangible" is not significant for fossil fuel companies. In addition, according to the standardized coefficient, the ranking of the most effective factors for green energy companies is as follows: Cash & Equivalents, Employees, Property & Plant & Equipment (PPE), and Intangibles; while the ranking for fossil fuel companies is: Employees, Cash & Equivalents, Property & Plant & Equipment (PPE), and Inventories. Although the significance of the variables "Inventories" and "Intangible" is different between the two industries, the other three factors are significant and are ranked as the top three most effective factors.

Secondly, the sample groups of green energy companies and fossil fuel companies are applying the same units of measurement, making the horizontal comparison applicable for the coefficients of different significant independent variables. As shown in the chart (Figure 5-11), the values for the fossil fuel companies are set to be 1 for comparison. Except for the factor "employee", which has the same effect for the "Sales" in both industries, the effect of other factors varies significantly. The "Sales" of the green energy industry is more likely to be influenced by the factors "Cash & Equivalents" and "Intangible", while the "Sales" of the fossil fuel industry is more likely to be reliant on "Property & Plant & Equipment (PPE)".

Thirdly, the R-squared (R^2) and the adjusted R-squared of the first model for green energy companies and fossil fuel companies show a gap. The R-squared (R^2) and the adjusted R-squared of the model for the fossil fuel industry are much higher than that for the green energy industry. Therefore, since the explanatory capacity of the first model is less effective for the green energy companies, it can be assumed that there can be other factors influencing the industrial output of green energy companies, which can be the consequences of external impacts, such as the support from the social and financial movements on low-carbon economy transition.

Figure 5-11 Model One - Comparison of Regression Coefficients (the coefficients for the fossil fuel industry are set as "1", compared with the green energy industry)



To conclude, based on the results of building the first model, the green energy industry's and the fossil fuel industry's total output can be explained by input factors of production. Therefore, the H_0 (the green energy industry's and the fossil fuel industry's total output can not be explained by factors of production) can be rejected, and the H_1 (the green energy industry's and the fossil fuel industry's total output can be explained by factors of production) is assumed. This result from the analysis of green energy companies and fossil fuel companies supports the production theory and generates an effective model (production function) with the various production factors in the form of assets.

5.2.2. Model Two - Financing Sources Model

In this section, models will be built for the green energy and then for the fossil fuel industry with various financial sources, including Employees, Long-term Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus), and Retained Earnings.

First, the function for green energy companies is analyzed. In the second model, the result of Levene's Test of Equality of Error Variances is shown in the following table (Figure 5-12). The p-value (Sig.) is 0.538 (> 0.05). The homogeneity of variance for the dependent variable "Sales" of the green energy companies is assumed in this second model.

Figure 5-12 OLS - Model Two - Levene's Test of Equality of Error Variances - Green Energy Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Green Energy Companies			
F	df1	df2	Sig.
0.818	5	212	0.538
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + Employees + Long Term Debt + Contributed Capital + Retained Earnings + Year			

The results of multiple linear regression for green energy companies are shown in the table (Figure 5-13). At the significance level of 0.05, the statistically significant variables include Employees, Long-term Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus), and Retained Earnings. All these independent variables are significant and, therefore, are kept in the model. The second model which is built with the various financing methods for green energy companies is as follows (Equation 5-3).

Equation 5-3 Model Two - Built with Various Production Factors in the Form of Financing Sources - Green Energy Companies

$Y = f_2$(Employees, Long-term Debt, Contributed Capital, Retained Earnings)

$Y = A * \text{Employees}^{a1} * \text{Long-term Debt}^{a2} * \text{Contributed Capital}^{a3} * \text{Retained Earnings}^{a4}$

$LnY = Lna_0 + a_1*Ln(\text{Employees}) + a_2*Ln(\text{Long-term Debt}) + a_3*Ln(\text{Contributed Capital}) + a_4*Ln(\text{Retained Earnings})$

The R-squared (R^2) is 0.652, and the adjusted R-squared is 0.637, proving the statistical significance of independent variables in this second model for green energy companies. The dependent variable “Sales” of green energy companies can be effectively explained by the independent variables selected in this model.

The results of F-statistic (Figure 5-14) shows that all the coefficients of independent variables are not equal to zero, proving that these variables can explain the dependent variable “Sales” of green energy companies and can be kept in the model.

Figure 5-13 OLS - Model Two - Parameter Estimates - Green Energy Companies

Parameter Estimates							
Dependent Variable: Sales - Green Energy Companies							
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	7.297	0.795	9.173	0	5.729	8.865	0.288
Employees	0.401	0.036	11.179	0	0.33	0.472	0.375
Long Term Debt	0.058	0.011	5.262	0	0.036	0.08	0.117
Contributed Capital	0.202	0.067	3.025	0.003	0.07	0.333	0.042
Retained Earnings	0.035	0.005	6.981	0	0.025	0.045	0.19
[Year=2013.0]	0.007	0.199	0.035	0.972	-0.385	0.399	0
[Year=2014.0]	-0.028	0.188	-0.151	0.88	-0.399	0.342	0
[Year=2015.0]	0.064	0.19	0.337	0.736	-0.31	0.438	0.001
[Year=2016.0]	0.12	0.192	0.627	0.531	-0.258	0.499	0.002
[Year=2017.0]	0.141	0.197	0.713	0.476	-0.248	0.53	0.002

[Year=2018.0]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Figure 5-14 OLS - Model Two - Tests of Between-Subjects Effects - Green Energy Companies

Tests of Between-Subjects Effects

Dependent Variable: Sales - Green Energy Companies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	252.346[a]	9	28.038	43.376	0	0.652
Intercept	57.563	1	57.563	89.05	0	0.3
Employees	80.782	1	80.782	124.97	0	0.375
Long Term Debt	17.895	1	17.895	27.684	0	0.117
Contributed Capital	5.915	1	5.915	9.15	0.003	0.042
Retained Earnings	31.504	1	31.504	48.738	0	0.19
Year	0.834	5	0.167	0.258	0.935	0.006
Error	134.453	208	0.646			
Total	39941.26	218				
Corrected Total	386.798	217				

a. R Squared = .652 (Adjusted R Squared = .637)

According to standardized coefficients calculated with standardized variables, as shown in the following table (Figure 5-15), the factor which has the most effect on “Sales” of green energy companies is “Employees”, followed by Retained Earnings, Long-term Debt, and Contributed Capital (combined with preferred stock, common stock, and capital surplus).

Figure 5-15 OLS - Model Two - Standardized Parameter Estimates - Green Energy Companies

Parameter Estimates

Dependent Variable: Sales - Green Energy Companies (Z-score)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	

Intercept	0.022	0.102	0.215	0.83	-0.18	0.224	0
Employees (Z-score)	0.54	0.048	11.179	0	0.445	0.635	0.375
Long Term Debt (Z-score)	0.229	0.044	5.262	0	0.143	0.315	0.117
Contributed Capital (Z-score)	0.154	0.051	3.025	0.003	0.054	0.255	0.042
Retained Earnings (Z-score)	0.332	0.048	6.981	0	0.238	0.426	0.19
[Year=2013.0]	0.005	0.149	0.035	0.972	-0.288	0.299	0
[Year=2014.0]	-0.021	0.141	-0.151	0.88	-0.299	0.256	0
[Year=2015.0]	0.048	0.142	0.337	0.736	-0.232	0.328	0.001
[Year=2016.0]	0.09	0.144	0.627	0.531	-0.193	0.373	0.002
[Year=2017.0]	0.105	0.148	0.713	0.476	-0.186	0.397	0.002
[Year=2018.0]	0[a]	.	.	.	.	.	

a. This parameter is set to zero because it is redundant.

Next, the function for fossil fuel companies is analyzed. The results of Levene's Test of Equality of Error Variances applied to the dependent variable "Sales" of fossil fuel companies in the following table (Figure 5-16). The p-value (Sig.) is 0.995 (> 0.05). Therefore, it can be assumed that the variance for the dependent variable "Sales" of the fossil fuel companies in the second model fits the homogeneity.

Figure 5-16 OLS - Model Two - Levene's Test of Equality of Error Variances - Fossil Fuel Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Fossil Fuel Companies			
F	df1	df2	Sig.
0.082	5	436	0.995

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Employees + Long Term Debt + Contributed Capital + Retained Earnings + Dummy Variable + Year

The multiple linear regression process (Figure 5-17) shows that the statistically significant independent variables in the second model include Employees, Long-term Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus), and Retained Earnings. The details are shown in the following table. A dummy variable is also employed in the second model for fossil fuel companies. The value for coal companies is 1, and the value for oil & gas companies is 0. The p-value (Sig.) for this dummy variable is 0.000, proving that this dummy variable (coal = 1, oil & gas = 0) is effective in this model. The coefficient is negative, which means that coal companies have a lower output (sales) with the same condition of input factors compared to oil & gas companies. Based on the result, the second model, built with the various financing methods, for fossil fuel companies is as follows (Equation 5-4).

Equation 5-4 Model Two - Built with Various Production Factors in the Form of Financing Sources - Fossil Fuel Companies

$Y = f_2$(Employees, Long-term Debt, Contributed Capital, Retained Earnings, Dummy)

$Y = A * \text{Employees}^{a1} * \text{Long-term Debt}^{a2} * \text{Contributed Capital}^{a3} * \text{Retained Earnings}^{a4} * e^{\text{Dummy (coal = 1, oil \& gas = 0)}}$

$LnY = Lna_0 + a_1*Ln(\text{Employees}) + a_2*Ln(\text{Long-term Debt}) + a_3*Ln(\text{Contributed Capital}) + a_4*Ln(\text{Retained Earnings}) + \text{Dummy (coal = 1, oil \& gas = 0)}$

The R-squared (R^2) is 0.897, and the adjusted R-squared is 0.895. The dependent variable "Sales" of fossil fuel companies can be effectively explained by the independent variables selected in this model.

The results of F-statistic (Figure 5-18) shows that all the coefficients of independent variables in the second model for fossil fuel companies are not equal to zero, proving that these variables can explain the dependent variable "Sales" for fossil fuel companies and, therefore, can be kept in the model.

Figure 5-17 OLS - Model Two - Parameter Estimates - Fossil Fuel Companies

Parameter Estimates
Dependent Variable: Sales - Fossil Fuel Companies

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	2.257	0.45	5.016	0	1.372	3.141	0.055
Employees	0.584	0.029	20.177	0	0.527	0.64	0.486
Long Term Debt	0.437	0.039	11.102	0	0.36	0.515	0.222
Contributed Capital	0.137	0.041	3.338	0.001	0.056	0.217	0.025
Retained Earnings	0.008	0.004	2.416	0.016	0.002	0.015	0.013
Coal=1; Oil & Gas=0	-0.702	0.107	-6.546	0	-0.913	-0.491	0.09
[Year=2013.0]	0.034	0.172	0.196	0.845	-0.304	0.371	0
[Year=2014.0]	0.077	0.121	0.639	0.523	-0.16	0.315	0.001
[Year=2015.0]	-0.342	0.12	-2.844	0.005	-0.579	-0.106	0.018
[Year=2016.0]	-0.427	0.12	-3.56	0	-0.664	-0.191	0.029
[Year=2017.0]	-0.19	0.12	-1.58	0.115	-0.427	0.046	0.006
[Year=2018.0]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Figure 5-18 OLS - Model Two - Tests of Between-Subjects Effects - Fossil Fuel Companies

Tests of Between-Subjects Effects

Dependent Variable: Sales - Fossil Fuel Companies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2232.317[a]	10	223.232	377.054	0	0.897
Intercept	13.721	1	13.721	23.175	0	0.051
Employees	241.019	1	241.019	407.098	0	0.486
Long Term Debt	72.973	1	72.973	123.257	0	0.222
Contributed Capital	6.597	1	6.597	11.142	0.001	0.025
Retained Earnings	3.455	1	3.455	5.836	0.016	0.013
Coal=1; Oil & Gas=0	25.366	1	25.366	42.845	0	0.09
Year	16.213	5	3.243	5.477	0	0.06
Error	255.17	431	0.592			
Total	108149.233	442				
Corrected Total	2487.487	441				

a. R Squared = .897 (Adjusted R Squared = .895)

According to standardized coefficients calculated with standardized independent variables (Figure 5-19), the factor which has the most effect on “Sales” of fossil fuel companies is “Employees”, followed by Long-term Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus), and Retained Earnings.

Figure 5-19 OLS - Model Two - Standardized Parameter Estimates - Fossil Fuel Companies

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	0.117	0.037	3.177	0.002	0.045	0.189	0.023
Employees (Z-score)	0.545	0.027	20.177	0	0.492	0.598	0.486
Long Term Debt (Z-score)	0.416	0.037	11.102	0	0.342	0.489	0.222
Contributed Capital (Z-score)	0.084	0.025	3.338	0.001	0.035	0.134	0.025
Retained Earnings (Z-score)	0.041	0.017	2.416	0.016	0.008	0.075	0.013
Coal=1; Oil & Gas=0	-0.286	0.044	-6.546	0	-0.372	-0.2	0.09
[Year=2013.0]	0.014	0.07	0.196	0.845	-0.124	0.151	0
[Year=2014.0]	0.031	0.049	0.639	0.523	-0.065	0.128	0.001
[Year=2015.0]	-0.139	0.049	-2.844	0.005	-0.236	-0.043	0.018
[Year=2016.0]	-0.174	0.049	-3.56	0	-0.27	-0.078	0.029
[Year=2017.0]	-0.077	0.049	-1.58	0.115	-0.174	0.019	0.006
[Year=2018.0]	0[a]	.	.	.	.	.	

Parameter Estimates — Dependent Variable: Sales - Fossil Fuel Companies (Z-score)

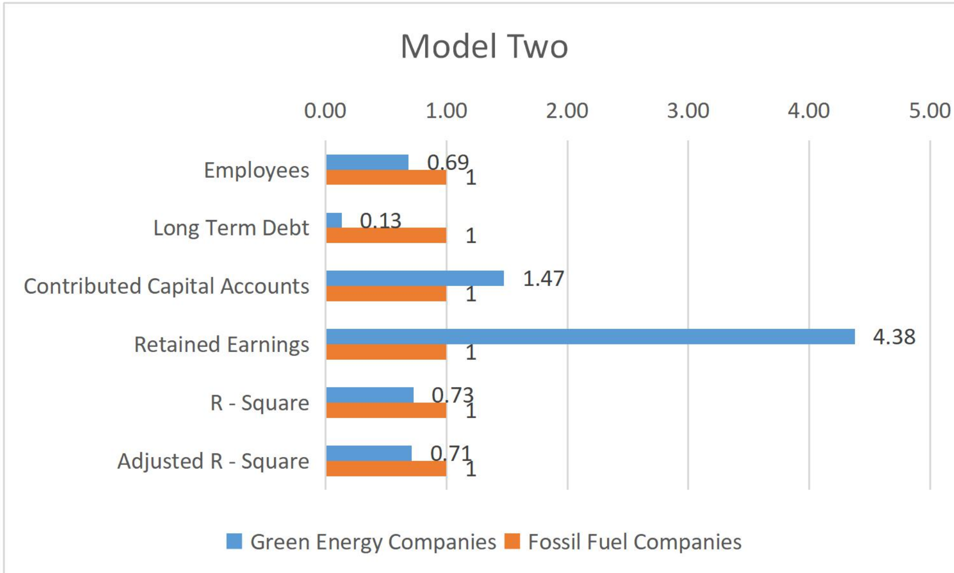
a. This parameter is set to zero because it is redundant.

The second models for green energy and fossil fuel companies are compared. Firstly, all the funding resource (independent variables) in the second model are significant for both the green energy industry and the fossil fuel industry. However, the ranking is different on which funding source (independent variables) have greater effects on the “sales” (dependent variable) between these two sample groups. The factor “Employees” has the greatest effect on both industries in the second model. The factor “Retained Earnings” ranks second in the model for the green energy industry, followed by Long-term Debt and Contributed Capital (combined with preferred stock, common stock, and capital surplus). However, in the model for the fossil fuel industry, “Retained Earnings” ranks as the factor with the least effect, ranking after Long-term Debt and Contributed Capital.

Secondly, since the sample groups of green energy companies and fossil fuel companies are applying the same units of measurement, the horizontal comparison between the coefficients of the two industries is also applicable. As shown in the chart (Figure 5-20), the values for the fossil fuel companies are set to be 1 for comparison. The factor “Retained Earnings” has much more influence on the “Sales” of green energy companies compared to fossil fuel companies. The factor “Contributed Capital”, which includes preferred stock, common stock, and capital surplus, has more influence on the “Sales” of green energy companies, while the factor “Long-term Debt” has more influence on the “Sales” of fossil fuel companies. These two factors represent two major financing methods, which are equity and debt.

Thirdly, similar to the first model, there is a gap between the R-squared (R^2) and the adjusted R-squared of the second model for green energy companies and fossil fuel companies. The R-squared (R^2) and the adjusted R-squared of the model for the fossil fuel industry are much higher than that for the green energy industry. Therefore, similar to the finding in the first model, it can be assumed that there can be other factors influencing the industrial output of green energy companies, as the explanatory capacity of the second model is less effective for the green energy companies compared to that for the fossil fuel companies as well.

Figure 5-20 Model Two - Comparison of Regression Coefficients (the coefficients for the fossil fuel industry are set as “1”, compared with the green energy industry)



To conclude, based on the results of building the first model, the green energy industry's and the fossil fuel industry's total output can be explained by input factors of production. The H_0 (the green energy industry's and the fossil fuel industry's total output can not be explained by various financing methods) can be rejected, and the H_1 (the green energy industry's and the fossil fuel industry's total output can be explained by various financing methods) is assumed. Along with the first model, the result of the second model for green energy companies and fossil fuel companies also provide support to the production theory and, meanwhile, generates an effective model (production function) built with the various financing methods.

5.2.3. Year Effect

The regression is conducted on the panel data, and the factor "Year" is set as the dummy variable. There is no significant year effect on the "Sales" of green energy companies during the period of this study from 2013 - 2018. In comparison, not every year from 2013 - 2018 has a significant year effect on the "Sales" of fossil fuel companies, but the year 2015 and 2016 have significant coefficients in the two models. The coefficients of these two years are negative, which means that with the same condition of various production factors or various sources of financing, the sales of the fossil fuel industry (coal, oil, and gas) are lower. This finding matches the decrease in stock price and demand in the fossil fuel industry in these two years.

5.3. Granger Causality Test

This step tries to explore the interrelation between the various input factors ("real economic factors") and the industrial output based on the sample of the biggest global fossil fuel companies (Carbon Underground 200). The study of the interrelation tires to discover the lagged effect between various input factors ("real economic factors") and the industrial output; to support the concepts shifting of capital flow and/or stranded assets; and, to find out the direction of causality between these two concepts.

5.3.1. Lag the "Various Factors of Production"

In this step, the various variables of production factors are lagged to study the effect of these lagged factors on the "Sales" of the fossil fuel industry in the two models. The year effect in these two models will not be discussed.

In the first model, which is built with various production factors in the form of assets, the results of the lagged regression are in the following tables (Figure 5-21, Figure 5-22). The dependent variable "Sales" passes the test of variance homogeneity, with the p-value (Sig.) of 0.714 (> 0.05). The result of the regression shows that only the variables "Employees" and "Property & Plant & Equipment (PPE)" are significant. The R-squared (R^2) and the adjusted R-squared are 0.903 and 0.900, respectively.

Figure 5-21 Lagged OLS - Lag the "Various Factors of Production" - Model One - Levene's Test of Equality of Error Variances - Fossil Fuel Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Fossil Fuel Companies (t+1)			
F	df1	df2	Sig.
0.53	4	364	0.714
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			

a. Design: Intercept + Employees + PPE + Intangibles + Inventories + Cash & Equivalents + Dummy Variable + Year

Figure 5-22 Lagged OLS - Lag the "Various Factors of Production" - Model One - Parameter Estimates - Fossil Fuel Companies

Parameter Estimates

Dependent Variable: Sales - Fossil Fuel Companies (t+1)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	-1.003	0.451	-2.223	0.027	-1.89	-0.116	0.014
Employees	0.199	0.037	5.349	0	0.126	0.272	0.074
PPE	0.885	0.038	23.155	0	0.81	0.961	0.6
Intangibles	0.008	0.008	1.063	0.289	-0.007	0.024	0.003
Inventories	0.016	0.011	1.44	0.151	-0.006	0.037	0.006
Cash & Equivalents	0.035	0.019	1.836	0.067	-0.002	0.072	0.009
Coal=1; Oil & Gas=0	0.094	0.115	0.818	0.414	-0.132	0.32	0.002
[Year=2013.0]	0.014	0.164	0.087	0.931	-0.308	0.337	0
[Year=2014.0]	-0.406	0.118	-3.444	0.001	-0.639	-0.174	0.032
[Year=2015.0]	-0.576	0.118	-4.867	0	-0.809	-0.343	0.062
[Year=2016.0]	-0.207	0.119	-1.745	0.082	-0.441	0.026	0.008
[Year=2017.0]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

R Squared = .903 (Adjusted R Squared = .900)

In the second model, which is built with various production factors in the form of equities and debts, the results of the lagged regression are in the following tables (Figure 5-23, Figure 5-24). The dependent variable "Sales" also passes the test of variance homogeneity, with the p-value (Sig.) of 0.900 (> 0.05). The result of regression shows that the variables "Employees", "Long-term Debt", and "Contributed Capital (combined with preferred stock, common stock, and capital surplus)" are significant. In addition, the dummy variable (coal = 1, oil & gas = 0) is also significant, with a negative coefficient. The R-squared (R^2) and the adjusted R-squared are 0.884 and 0.881, respectively.

Figure 5-23 Lagged OLS - Lag the “Various Factors of Production” - Model Two - Levene's Test of Equality of Error Variances - Fossil Fuel Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Fossil Fuel Companies (t+1)			
F	df1	df2	Sig.
0.265	4	354	0.9

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Employees + Long Term Debt + Contributed Capital + Retained Earnings + Dummy Variable + Year

Figure 5-24 Lagged OLS - Lag the “Various Factors of Production” - Model Two - Parameter Estimates - Fossil Fuel Companies

Parameter Estimates

Dependent Variable: Sales - Fossil Fuel Companies (t+1)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	1.778	0.54	3.295	0.001	0.716	2.839	0.03
Employees	0.54	0.035	15.312	0	0.471	0.609	0.402
Long Term Debt	0.502	0.047	10.8	0	0.411	0.594	0.251
Contributed Capital	0.126	0.049	2.576	0.01	0.03	0.223	0.019
Retained Earnings	0.006	0.004	1.479	0.14	-0.002	0.015	0.006
Coal=1; Oil & Gas=0	-0.704	0.129	-5.444	0	-0.958	-0.45	0.078
[Year=2013.0]	0.203	0.19	1.067	0.287	-0.171	0.577	0.003
[Year=2014.0]	-0.262	0.133	-1.963	0.05	-0.524	0.001	0.011
[Year=2015.0]	-0.47	0.132	-3.57	0	-0.73	-0.211	0.035
[Year=2016.0]	-0.079	0.131	-0.605	0.546	-0.337	0.178	0.001
[Year=2017.0]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

R Squared = .884 (Adjusted R Squared = .881)

Therefore, to conclude the results shown above, the factors “Employees”, “Property & Plant & Equipment (PPE)”, “Long-term Debt”, and “Contributed Capital (combined with preferred stock, common stock, and capital surplus)” have significant effect on the next-year “Sales” of the fossil fuel companies. It can be assumed that the decrease in these factors has a negative influence on the next-year sales in the fossil fuel industry. This helps to support the concept of shifting of capital flow, as the shifting of the capital flow will negatively affect the acquisition of factors mentioned above, and consequently negatively affect the industrial sales and output in the future.

5.3.2. Lag the “Industrial Output”

In this step, the “Sales” of the fossil fuel industry is lagged in the two models to study the effect of lagged “Sales” on the future various variables of production factors. The year effect in these two models is also not discussed.

In the first model, which is built with various production factors in the form of assets, the results of the lagged regression are in the following tables (Figure 5-25, Figure 5-26). The dependent variable “Sales” passes the test of variance homogeneity, with the p-value (Sig.) of 0.705 (> 0.05). The result of regression shows that the variables “Employees”, “Property & Plant & Equipment (PPE)”, and “Inventories” are significant. The R-squared (R^2) and the adjusted R-squared are 0.941 and 0.940, respectively.

Figure 5-25 Lagged OLS - Lag the “Industrial Output” - Model One - Levene's Test of Equality of Error Variances - Fossil Fuel Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Fossil Fuel Companies (t-1)			
F	df1	df2	Sig.
0.542	4	414	0.705
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			

a. Design: Intercept + Employees + PPE + Intangibles + Inventories + Cash & Equivalents + Dummy Variable + Year

Figure 5-26 Lagged OLS - Lag the "Industrial Output" - Model One - Parameter Estimates - Fossil Fuel Companies

Parameter Estimates

Dependent Variable: Sales - Fossil Fuel Companies (t-1)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	-0.082	0.312	-0.262	0.793	-0.696	0.532	0
Employees	0.302	0.028	10.737	0	0.247	0.358	0.22
PPE	0.776	0.026	29.703	0	0.724	0.827	0.684
Intangibles	0.003	0.006	0.547	0.585	-0.008	0.014	0.001
Inventories	0.024	0.008	3.152	0.002	0.009	0.039	0.024
Cash & Equivalents	0.019	0.012	1.511	0.132	-0.006	0.043	0.006
Coal=1; Oil & Gas=0	-0.003	0.083	-0.038	0.97	-0.167	0.16	0
[Year=2014.0]	0.027	0.09	0.296	0.767	-0.15	0.204	0
[Year=2015.0]	0.177	0.09	1.954	0.051	-0.001	0.354	0.009
[Year=2016.0]	-0.158	0.091	-1.734	0.084	-0.336	0.021	0.007
[Year=2017.0]	-0.28	0.091	-3.081	0.002	-0.458	-0.101	0.023
[Year=2018.0]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

R Squared = .941 (Adjusted R Squared = .940)

In the second model, which is built with various production factors in the form of equities and debts, the results of the lagged regression are in the following tables (Figure 5-27, Figure 5-28). The dependent variable "Sales" also passes the test of variance homogeneity, with the p-value (Sig.) of 0.970 (> 0.05). The result of regression shows that all the variables in the second model are significant, including "Employees", "Long-term Debt", "Contributed Capital (combined with preferred stock, common stock, and capital surplus)", and "Retained Earnings". In addition, the dummy variable (coal = 1, oil & gas = 0) is also significant, with a negative coefficient. The R-squared (R^2) and the adjusted R-squared are 0.903 and 0.900, respectively.

Figure 5-27 Lagged OLS - Lag the “Industrial Output” - Model Two - Levene's Test of Equality of Error Variances - Fossil Fuel Companies

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Sales - Fossil Fuel Companies (t-1)			
F	df1	df2	Sig.
0.134	4	407	0.97
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + Employees + Long Term Debt + Contributed Capital + Retained Earnings + Dummy Variable + Year			

Figure 5-28 Lagged OLS - Lag the “Industrial Output” - Model Two - Parameter Estimates - Fossil Fuel Companies

Parameter Estimates							
Dependent Variable: Sales - Fossil Fuel Companies (t-1)							
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	1.888	0.442	4.267	0	1.018	2.757	0.043
Employees	0.59	0.028	21.272	0	0.536	0.645	0.53
Long Term Debt	0.504	0.041	12.269	0	0.424	0.585	0.272
Contributed Capital	0.079	0.04	1.97	0.05	0	0.157	0.01
Retained Earnings	0.007	0.003	2.135	0.033	0.001	0.014	0.011
Coal=1; Oil & Gas=0	-0.629	0.104	-6.057	0	-0.833	-0.425	0.084
[Year=2014.0]	0.098	0.111	0.882	0.378	-0.12	0.316	0.002
[Year=2015.0]	0.208	0.111	1.88	0.061	-0.01	0.425	0.009
[Year=2016.0]	-0.099	0.11	-0.893	0.372	-0.315	0.118	0.002
[Year=2017.0]	-0.297	0.111	-2.683	0.008	-0.514	-0.079	0.018
[Year=2018.0]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

R Squared = .912 (Adjusted R Squared = .910)

Therefore, to conclude the results shown above, the factors “Employees”, “Property & Plant & Equipment (PPE)”, “Inventories”, “Long-term Debt”, “Contributed Capital (combined with preferred stock, common stock, and capital surplus)”, and “Retained Earnings” have significant effect on the lagged (previous-year) “Sales” of the fossil fuel companies. It can be assumed that the decrease in the sales of the fossil fuel industry in the previous year has a negative influence on the various variables of production factors in the next year. This helps to support the concept of stranded assets, as the decrease of sales or market demand in the previous year will negatively affect the next-year value and holding of various factors of production which are in the various forms of assets, debts, and equities.

5.3.3. Comparison between the Lagged Models with Lagged “Various Factors of Production” & Lagged “Industrial Output”

Since the lagged factors (lagged “various factors of production” & lagged “industrial output”) are respectively significant in both lagged OLS models of Granger causality tests. A bi-directional “causality” between “various factors of production” and “Sales” is found in this study. By comparing the R-squared (R^2) and the adjusted R-squared between different models with different lagged variable, it can be found that although the R-squared (R^2) and the adjusted R-squared of the models with lagged “Sales” of the fossil fuel industry is higher, the differences between models with lagged “Sales” and models with lagged “various factors of production” are small.

These models with lagged “various factors of production” and lagged “Sales” help to support the concept shifting of capital flow and stranded assets, respectively. Therefore, when it comes to answering the question of “what is the direction of causality between the concepts of shifting of capital flow and stranded assets”, the bi-directional interaction is assumed. The shifting of capital flow precedes and contributes to stranded assets, and the stranded assets also precede and contribute to shifting of capital flow.

5.4. Weakness of This Study - Endogenous Issue

The endogeneity has always been an issue of concern for model building in the quantitative research, especially those which are trying to prove the “casual impact” between variables. This research studied the interaction between the two concepts of shifting of capital flow and stranded assets, and discovered the “bi-directional causality” with the Granger causality test. In this section, the potential endogenous issue of this study will be discussed.

Firstly of all, the endogenous issue is lead by three deficiencies in research: omitted variables, co-determination, and measurement errors. In this study, the issue of measurement errors is less likely, since the data source is the 10K (annual report) or 10Q (quarterly report) filed by companies with the U.S. Securities and Exchange Commission (SEC) and therefore, the authenticity and accuracy of the data adopted in this research can be guaranteed. However, the other two issues, which are omitted variables and co-determination, are likely to exist. The omitted variable issue is the missing variable which influences both the dependent variable as well as the independent variables; and, the co-determination issue is that the dependent variable and the independent variables have bilateral causal determination on each other. This research tries to settle the potential endogeneity issue in the following way.

As discussed in the previous section (section 4.6.2), the “causality” mentioned here is not corresponding with the notions of causation, for instance, in physics. Although by conducting the Granger causality test, there are “bi-directional interactions” found between the “input factors of production” and “Output”, as well as between the two concepts of shifting of capital flow and stranded assets, the Granger-causality between two variables can not be interpreted as the changing of one variable “causes” the other variable to change. Instead, the results of this interaction should be interpreted as one variable “precedes”, “contributes to”, or “helps to predict” the other one. In this study, this interaction is bi-directional, but this bi-directional interaction does not mean the co-determination issue, which is one of the causes of endogeneity.

Besides, to settle the potential endogenous concerns, lagged OLS is conducted in this study, which is a method always employed in social science for causal identification, especially on panel data (Bellemare et al., 2015). However, this processing method has been controversial. Bellemare et al. (2015) pointed out that, by lagging the explanatory variables to solve the endogenous issue, the problem is shifting from the endogeneity concern to the assumption of “no dynamics among unobservables”, which can be an untestable assumption.

To conclude, the endogenous issue has always been a problem that is difficult to solve completely, making the models built in the research less reliable. However, this study has taken measures to lower the influence of endogeneity. The models and regression coefficients acquired in this research still have reference values.

6. Conclusions

This study provides supports to the two concepts, shifting of capital flow and stranded assets, which support the rationality of fossil fuel divestment and other social and financial movements for the low-carbon economy transition. These two concepts also justify the divestment strategy in relation to moral and financial concerns. Two models are built to explore the influence of various factors of production, which are in the form of assets (model one) and debts & equities (model two), on the industrial output of the fossil fuel industry as well as the green energy industry. The two models also help to explore the interaction between these two concepts.

Firstly, the descriptive statistics show the changes in the quantity level of some industry indicators for the fossil fuel industry and the green energy industry. This study explores four aspects of indicators, that is labor, assets, debts & equities, and profitability. All these indicators provide evidences that the green energy industry is a growing industry, while the fossil fuel industry is a mature and probably, declining industry. The transition to a low-carbon economy may accelerate the growth of the green energy industry and the decline of the fossil fuel industry. This can be in line with various factors. For example, the CO_2 emissions and the consumption of fossil fuel reserves has to be heavily restricted to mitigate the climate changing (Carbon Tracker Initiative, 2011; McGlade & Ekins, 2015; Meinshausen et al., 2009); there is increasing belief that the lending practices of banks are responsible for negative environmental impacts from the project they supported (Sarokin & Schulkin, 1991; Gray & Bebbington. 2001); also, there are increasing challenges coming from the low-carbon economic transition (Ansar et al., 2014; Carbontracker, 2015; Weber & Kholodova, 2017) and the upcoming environment or climate regulations (Richardson, 2009), the increasing attention from stakeholders (Dordi & Weber, 2019), and growing demand for socially responsibly investment (US SIF Foundation, 2018) and impact investing (Kennedy, 2018).

Next, this study built two models based on the production theory and the Cobb-Douglas production function (Cobb & Douglas, 1928), which is introducing a new method to explore the influence of the financial capital on the industrial output of the fossil fuel industry as well as the green energy industry. The first model was closely based on the theory of production, and the second model was derived from the first model. The independent variables in the first model represent the existence form of the input factors, including various production factors in the form of assets, while the independent variable in the second model represents the financial sources of these input factors, including various financing methods. The standardized coefficients are also employed to rank the influences of various factors on the sales of the two industries. Besides, the R-squared (R^2) and the adjusted R-squared of the two models showed that the factors selected in these models have a better explanatory ability for fossil fuel companies (about 0.9) compared to green energy companies (about 0.6). Therefore, it is expected that there can be an omitted significant factor influencing the industrial output in the models for the green energy industry, as listed in the last paragraph. There is a dummy variable (coal = 1, oil & gas = 0) in the two models for the fossil fuel industry, and this dummy variable is significant in the second model (built with the various financing methods) with a negative coefficient. Therefore, it can be suggested that coal companies have a lower capacity of output (sales) with the same condition of financing sources compared to oil & gas companies. It is assumed that coal companies are relatively weak at the capacity of capital utilization and, therefore, can be more vulnerable to changes in the accessibility to financial capital. This is in line with the research finding of Ansar et al. (2013), which is fossil fuel divestment announcements may have more impact on coal companies compared to oil and gas companies due to oil and gas stocks have better liquidity compared to coal stocks. Since the regression was analyzing the panel data with the time period of 2013 to 2018, the year factor is set as dummy variables in each model. It is found that there was no significant year effect on the sales of the green energy industry, but the years of 2015 and 2016 have significant coefficients in the two models for the fossil fuel industry. The coefficients of these two years are negative, which means that with the same condition of input factors, the sales of the fossil fuel industry (coal, oil, and gas) are lower in these two years. This can be explained by the decrease in stock prices in the fossil fuel industry as well as the decrease in demand for fossil fuel products in these two years.

To study the interaction between the “market demand & industrial output” and the “various factors of production (model one) & various financing methods (model two)”, the Granger Causation test (lagged OLS analysis) is conducted on the fossil fuel industry. A “bi-directional causality” (or “bi-directional feedback”) was found between the factors “Employees, Property & Plant & Equipment (PPE)” and the sales of the fossil fuel industry in model one, and between the factors “Employees, Long-term Debt, Contributed Capital (combined with preferred stock, common stock, and capital surplus)” and the sales of the fossil fuel industry in model two. This finding helps to support the concept of shifting of capital flow, as the decrease of these various factors of production and various financing sources in the fossil fuel industry will negatively influence the future market demand and industrial output of the fossil fuel companies. Fossil fuel divestment is one of the social and financial movements aiming to decrease the flow of financial capital to the fossil fuel industry, and therefore, this movement curbs the further business development of this industry.

Also, this finding helps to support the concept of stranded assets, as the decrease of the market demand and industrial output from the fossil fuel industry will have negative effects on the next-year various input factors of production and various financing sources for the fossil fuel companies, which curbs the further capital expansion of this industry. Therefore, it can be concluded that fossil fuel divestment may lead to a decrease in demand for the products and stocks from these fossil fuel companies, and other social and financial movements about low-carbon economy transition may lead to a limitation on the industrial output of fossil fuel products. These events may impair the value of the fossil fuel industry's assets, equities, and debts. One of the factors PPE in this study represents the book value of reserves, plants, and equipment for production in the fossil fuel industry, and is closely related to the concept of stranded assets.

The bi-directional interrelation shows that shifting the financial capital flow from the fossil fuel industry to the green energy industry can curb the exploration, production, and capitalization of the fossil fuel industry and promote the green energy industry, which is the purpose of socially responsible investors in the fossil fuel divestment and reinvestment process (Dordi & Weber, 2019). Also, fossil fuel companies are highly dependent on equity, and therefore, the stock price can be severely affected by the divestment and reinvestment movements (Braungardt et al., 2019). However, according to the study (Ansar et al., 2013) on the fossil fuel divestment strategies of various institutional funds in different fund markets such as the US, UK, Canada, Australia, and the European Union, it was found that the financial effect of divestment on GHG emission is not as expected. The reason is that the divested capital is low in quantity compared to the capitalization of fossil fuel companies, resulting in the effect on share prices of this industry less likely to be long-term. Also, there will be new investors buy-in and hold the divested shares. So far, the fossil fuel investment shows four preferable attributes, which are overall scale, liquidity, value growth, and dividend yield (Bullard, 2014), which can be appealing to investors motivated by financial benefits. However, this research is not to study the effectiveness of divestment from the perspective of market performance data, but to support the effectiveness by explaining the mechanism of this strategy. This study supports the divestment and reinvestment movements by supporting the two concepts, shifting of capital flow and stranded assets, which respectively relate to moral and financial concerns of socially responsible investors. Out of moral concerns, investors want to shift the capital flow to help limit the fossil fuel companies' business development and capital expansion. Also, these investors want to shift the capital flow from the fossil fuel industry to carbon-neutral industries, and the green energy industry can be one of the best alternatives. Moreover, the stranded assets are the investors' financial concerns, as the divestment movement may significantly decrease the demand and supply of fossil fuels and, therefore, depreciates the value of declared reserves as well as other assets of these fossil fuel companies.

The contributions of this study are in the following aspects. Firstly, the two models in this study support the production theory by applying this theory to build models for the green energy industry and the fossil fuel industry. Besides, the production theory is a conceptual model and remained controversial. This study identifies the key factors for the fossil fuel industry and the green energy industry and matches these factors with the accounting data in financial statements in the form of assets, equities, and debts. Compared to the fossil fuel industry (R-squares are about 0.9), the explanatory power of the two models is lower for the green energy industry (R-squares are about 0.6). As a growing industry, there can be other factors that significantly contribute to the production of the green energy industry.

Secondly, the Granger Causation test (lagged OLS analysis) discovers the positive and significant bi-directional interrelation between the input factors of production and the industrial output for the fossil fuel industry. As discussed above, the results help to support the concept of shifting of capital flow and stranded assets. The results also can explain the interaction between these two concepts. The shifting of capital flow precedes (contributes to, helps to predict) the stranded assets because the social and financial movements (such as divestment) encourage the moral investors withdrawing the financial capital from the fossil fuel industry, making the various input factor for this industry less available or decrease in holdings. Then, the industrial sales will decrease, leading to the holding value of various input factors in the fossil fuel industry decrease further, which leads to stranded assets. In the opposite direction, the stranded assets also precede (contribute to, help to predict) shifting of capital flow because the investors with financial concerns predict the future restrictions on the production and consumption of fossil fuels will lead to the decrease of market demands as well as the supply. The decreases in sales or limitations on fossil fuel production will lead to the difficulty in industry business development and capital expansion and even lead to the decline of the industry. The holding of various factors of production in the form of assets, equities, and debt will decrease in value, leading to further weakening of industrial production ability, which is also the consequence of shifting of capital flow.

Based on this bi-directional influence between the shifting of capital flow and stranded assets, the relationship between moral concerns and financial concerns of the investors can also be explained. Out of moral concerns, investors want to shift the capital flow to help limit the fossil fuel companies' business development and capital expansion, and out of financial concerns, investors hope to avoid the risks of stranded assets which result from the divestment movement. The moral concern may precede the financial concern because investors who divest out of moral concerns are also avoiding the potential financial risks such as stranded assets, and investors who divest out of financial concerns are also fulfilling the moral responsibility by shifting the financial capital form the industry which is recognized as the main cause of climate change.

Therefore, the findings of this study provide the rationality of fossil fuel divestment from a new perspective. The previous studies mainly focus on divestment or divest-reinvest portfolios while answering the question of "whether divestment can meet both financial and moral demands from investors" and assess the financial performance and carbon intensity of these portfolios with the data of market performance. This study explores the mechanism of fossil fuel divestment by discovering the interaction between the concepts of shifting of capital flow and stranded assets, as well as the relationship between moral and financial concerns. The justified moral and financial concerns can encourage institutional investors to make invest-reinvest decisions, as well as supporting policymakers and campaign initiators taking actions to curb the fossil fuel industry while supporting the green energy sector.

Thirdly, the models built in this study also have practical values. The two models, which are built with various factors of production and various financing sources respectively, can not only help to predict the expected industrial output of the two industries and the possible influence of the social & financial movements, the coefficient of each variable also has reference value for the low-carbon economy transition and the development of responsible investment products. The reasons are as follows.

The first model, which is built with various input factors of production, can help with the transform of the fossil fuel industry. As the standardized coefficients suggest, firstly, the factor of “employee” has a great contribution to the productions of the two industries. Therefore, the development of the green energy industry depends highly on human resources, and the transformation of the fossil fuel industry depends highly on human resources as well. Secondly, as the factor “Property & Plant & Equipment (PPE)” in this study represents the book value of reserves, plants, and equipment for production in the fossil fuel industry, and this factor is likely to become stranded assets resulting from the fossil fuel divestment and other social and financial movements. The standardized coefficient of PPE ranks the highest in the model for the fossil fuel industry and ranks relatively low in the model for the green energy industry. Therefore, the production of fossil fuel is more dependent on PPE than that of green energy. If the fossil fuel industry wants to transition to the green industry, some parts of PPE, such as fossil fuel reserves and equipment, need to be replaced. However, since the production of green industries does not depend highly on PPE (compared to cash & equivalents and employees), the capital requirements for additional PPE during the transformation process are not particularly critical. Instead, the factor of “intangibles” has a significant influence on the production of the green energy industry. Therefore, the purchase of intangible assets (including goodwill, brand recognition, or intellectual property) can be necessary during the transition process. Thirdly, the standardized coefficients suggest that the factor “cash & equivalents” has the biggest influence on the production of the green energy industry. This is not a serious problem for the fossil fuel industry. The reason is that the fossil fuel companies in this study are the top 100 biggest coal or oil & gas companies which usually have good credit ratings, making it easier for these companies to finance. The reason for the green energy industry relying on cash & equivalents the most is that these companies are growing companies and may require good short-term debt solvency, and the cash & equivalents are the most liquid assets.

The second model, which is built with various financing sources, can help with the development of responsible investment products. The regression coefficients for “Contributed Capital” and “Long-term Debt”, which respectively represent financing through equities and financing through debts, can help the investors to assess if their investment portfolios contribute more to the development of the green industry or the development of the fossil fuel industry. Contributed capital consists of preferred stocks, common stocks, and capital surpluses, and the long-term debt includes bonds, mortgages, bank loans, debentures, etc. Besides, the findings show that, for both industries, the factor “Long-term Debt” has more influence on the sales compared to “Contributed Capital”, which means that the “green credit” can be greatly effective in the low-carbon economy transition progress.

The limitation of this study can be the potential endogeneity issue, although lagged OLS is employed to tackle endogeneity in the two models, which is a method always employed in social science to tackle the challenge of causal identification on panel data (Bellemare et al., 2015). However, this method is solving the endogeneity issue by making an additional assumption. That is, there are no dynamics among unobserved variables, which can be an untestable assumption. Besides, the Granger Causality test only helps to prove the correlation between one variable and another lagged variable. It can not prove that one variable changes will “cause” the other variable to change (Brooks, 2002), which is different from the “standard notions of causation” (Scholtens, 2008). Therefore, the interrelationship between the two concepts shifting of capital flow explains the stranded assets should be recognized as “positive and significant interaction” and “bi-directional feedback & causality”, which is similar to the study on the interaction between corporate social responsibility (CSR) and financial performance (CFP) (Scholtens, 2008). Although the bi-directional influence can not justify the co-determination, as one of the causes of the endogenous issue, between these two concepts, it is still possible that these two concepts are co-determined. Also, there is a possibility that there is an omitted variable that has influences on both independent and dependent variables, leading to another aspect of the endogenous problem. The study on the interaction between corporate social responsibility (CSR) and financial performance (CFP) also suggested that there can be an omitted variable unobserved. The later “Institutional Theory” justified that the influence of institutions and stakeholders can be the omitted variable that has a uni-directional influence on both CSR and CFP. Therefore, future research is necessary to identify the omitted unobserved variable which has a significant influence on both shifting of capital flow and stranded assets. The author assumes that the “Institutional Theory” can also be applicable in this case, which means that the pressure from institutions and stakeholders can significantly contribute to both shifting of capital flow and stranded assets.

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Appendices

Appendix A: Descriptive Statistics for Each Variable

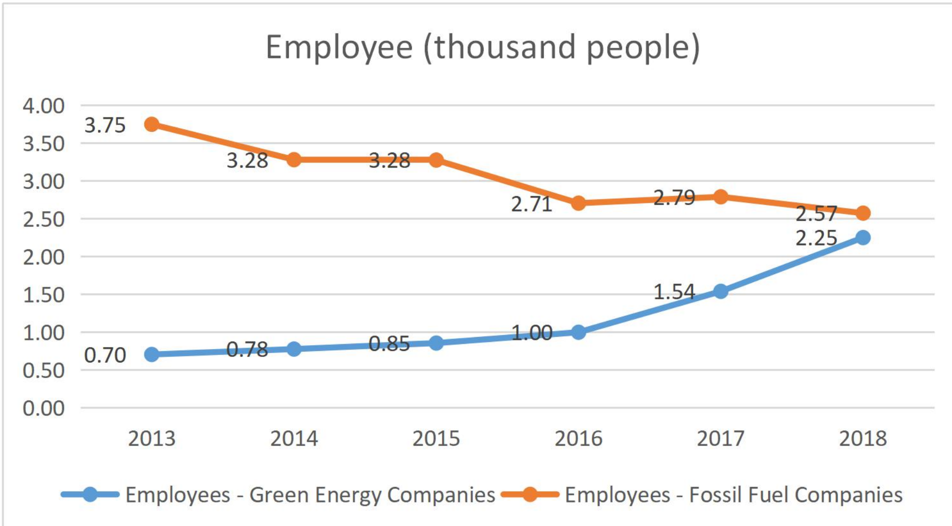
Descriptive Statistics - Green Energy Companies

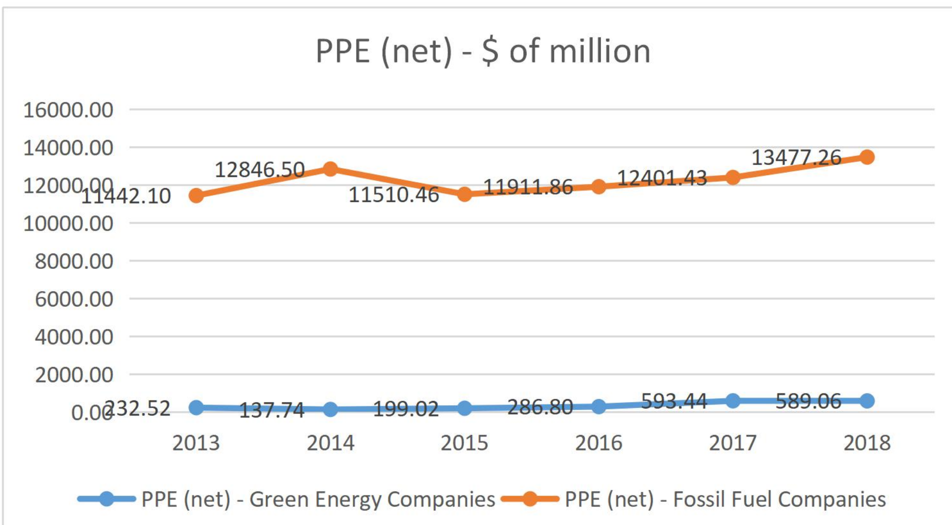
Year		Employees - Green Energy Companies	PPE (net) - Green Energy Companies	Intangibles - Green Energy Companies	Inventories (Total) - Green Energy Companies	Cash & Equivalents - Green Energy Companies	Long Term Debt - Green Energy Companies	Contributed Capital - Green Energy Companies	Retained Earnings - Green Energy Companies	Sales (Net) - Green Energy Companies	Net Income (Loss) - Green Energy Companies
2013	N	35	40	40	40	40	40	40	39	40	40
	Mean	4.0486	553.6205	127.97903	135.59928	312.76505	346.94929	722.67979	-63.84428	982.68323	14.92393
	Variance	29.411	701554.97	62192.382	26544.253	127281.86	369189.87	472280.4	386675.51	856339.85	20244.295
	Std. Deviati	5.423202	837.58878	249.38401	162.92407	356.76583	607.60997	687.2266	621.83238	925.38633	142.28245
	Minimum	0	0	0	0	3.096	0	0	-1261.75	24.445	-321.196
	Maximum	21	4490.553	999.073	596.75	1386.573	2953.705	3188.75	1758.361	3308.989	406.925
	Grouped Me	0.7035	232.5235	41.75025	64.27675	153.44825	136.104	507.18925	-58.7005	582.361	5.376
2014	N	43	44	43	44	44	44	44	43	44	44
	Mean	3.81212	588.18458	139.89291	152.40835	343.62581	418.89942	784.83449	-101.5657	1068.4795	44.77091
	Variance	29.596	934460.91	63339.321	35569.153	180586.14	689684.03	504959.11	452777.36	1137727.9	19958.274
	Std. Deviati	5.440205	966.67518	251.67304	188.59786	424.95428	830.47217	710.60475	672.88733	1066.6433	141.27376
	Minimum	0	0	0	0	3.895	0	0	-1286.651	43.274	-294.04
	Maximum	23.25	5171.701	999.224	670.85	1914.978	3670.349	3251.2	2093.412	3391.814	459.961
	Grouped Me	0.775	137.7365	39.635	54.585	163.2225	80.54875	585.40425	-78.9505	583.049	14.047
2015	N	40	41	40	41	41	41	41	40	41	41
	Mean	4.16816	859.62284	184.41847	180.9999	391.81543	646.8871	891.53011	-52.42701	1184.6242	-19.53868
	Variance	32.636	1800669.8	97333.869	58226.155	204625.54	1272852.9	661068.02	732792.69	1302686.8	64231.568
	Std. Deviati	5.712814	1341.8904	311.98376	241.30096	452.35555	1128.2078	813.06089	856.03312	1141.353	253.43948
	Minimum	0	0	0	0	20.8	0	0	-1879.781	34.153	-888.663
	Maximum	24.5	5803.257	1314	1115.757	1984.294	4226	3356	2567.71	4046.025	546.421
	Grouped Me	0.8545	199.0225	54.486	60.8245	174.572	167.149	654.759	-33.63175	859.738	5.839
2016	N	37	39	38	39	39	39	39	38	39	39
	Mean	4.42693	1084.6654	221.67989	193.29863	450.75587	794.15126	1028.928	-25.09168	1337.17	14.87528
	Variance	42.637	3707422.1	147551.19	99483.218	283772.51	1690483.8	1177580.3	851018.97	2146901.7	37381.948
	Std. Deviati	6.52969	1925.4667	384.12393	315.4096	532.70303	1300.1861	1085.1637	922.5069	1465.2309	193.34412
	Minimum	0	0	0	0	23.289	0	0	-2673.428	56.463	-674.914
	Maximum	28.25	10115.827	1324	1672.646	2359.136	4994	5619.77	2629.481	7000.132	494.346
	Grouped Me	0.9975	286.804	73.07275	69.292	228.5595	240.8835	728.4	-50.741	715	27.101
2017	N	32	33	33	33	33	33	33	32	33	33
	Mean	5.8625	1607.5967	295.18488	257.00209	501.72124	1157.5214	1173.2544	34.60356	1792.2386	-30.95442
	Variance	73.798	10494558	206172.57	174207.92	526123.24	3485409.6	2381218.7	1256379	5058884.3	175006.06
	Std. Deviati	8.590578	3239.5306	454.0623	417.38222	725.34354	1866.9252	1543.1198	1120.8831	2249.1964	418.33726
	Minimum	0	0	0	0	13.895	0	10.022	-3980.964	70.089	-1961.4
	Maximum	33.784	17764.267	1616	2165.496	3510.986	7770.054	8480.468	2376.429	11758.751	810.7
	Grouped Me	1.53875	593.4355	82.93	82.271	266.674	442.016	717.8545	19.6185	1009	21.78
2018	N	36	37	37	37	37	37	37	36	37	37
	Mean	6.238	1822.3119	435.9743	289.01069	520.33809	1300.6837	1201.6495	175.17893	2015.7647	56.24997
	Variance	86.092	12455245	330674.69	239891	544163.07	4018579.8	2766969.2	1789726.9	12538810	95488.551
	Std. Deviati	9.27858	3529.199	575.0432	489.78669	737.67409	2004.6396	1663.4209	1337.8068	3541.0182	309.01222
	Minimum	0.048	0	0	0	46.4	0	10.022	-5133.501	90.459	-976.091
	Maximum	43.18	20091.424	1992.585	2688.492	3700.703	9470.152	9713.778	2343.287	21461.268	693.562
	Grouped Me	2.24975	589.06	122.0605	103.799	273.0205	501.028	703.296	164.665	1029.624	58.84
2019	N	3	3	3	3	3	3	3	3	3	3
	Mean	6.358	314.5755	791.328	213.76967	380.17917	246.04883	1667.322	61.3265	1616.4287	-24.00767
	Variance	35.969	98387.289	492973.12	31737.377	93346.74	43549.451	869372.11	2925975.3	3412964.6	124440.81
	Std. Deviati	5.997399	313.66748	702.12045	178.14987	305.52699	208.68505	932.40126	1710.5482	1847.4211	352.76169
	Minimum	0.517	18.467	53.542	23.302	126.245	5.647	918.65	-1170.364	96.586	-375.1
	Maximum	12.5	643.26	1451.3	376.3	719.243	380.55	2711.725	2014.4	3672.7	330.4
	Grouped Me	6.0575	282	869.142	241.7075	295.05	351.95	1371.591	-660.057	1080	-27.323
Total	N	226	237	234	237	237	237	237	231	237	237
	Mean	4.72295	1042.1577	235.81737	197.91289	414.44682	746.26778	963.2963	-10.00035	1373.9076	14.06606
	Variance	47.213	4743952.2	160203.57	100128.52	295281.82	1884700.5	1262761.3	882977.11	3682457.1	64191.047
	Std. Deviati	6.871194	2178.0616	400.25439	316.4309	543.39839	1372.844	1123.7265	939.66862	1918.9729	253.35952
	Minimum	0	0	0	0	3.096	0	0	-5133.501	24.445	-1961.4
	Maximum	43.18	20091.424	1992.585	2688.492	3700.703	9470.152	9713.778	2629.481	21461.268	810.7
	Grouped Me	0.981	282.411	60.73425	69.78	222.8945	204.8945	655.1625	-35.7675	807	16

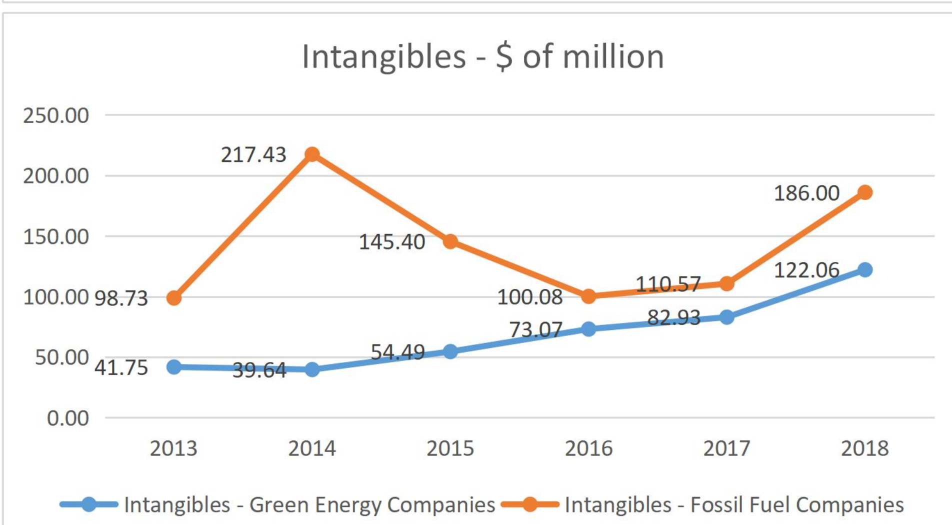
Descriptive Statistics - Fossil Fuel Companies

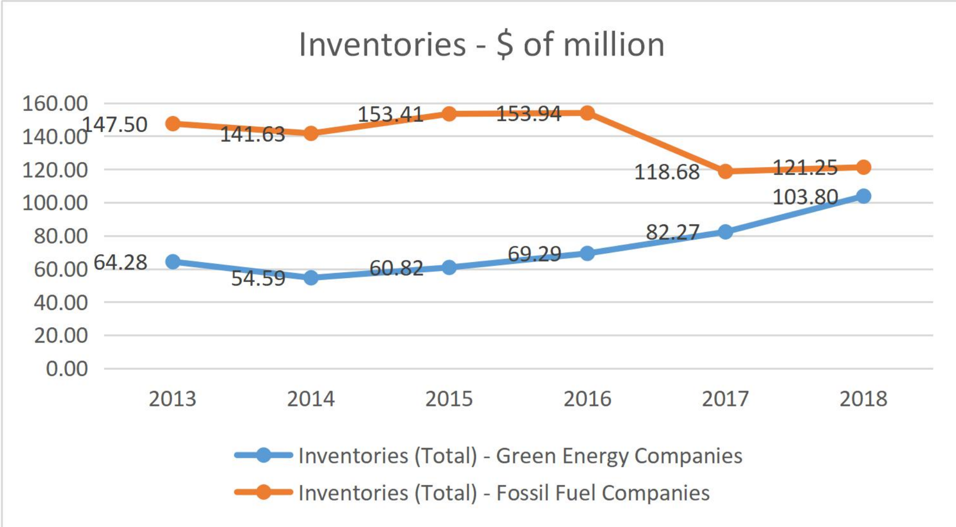
Year		Employees - Fossil Fuel Companies	PPE (net) - Fossil Fuel Companies	Intangibles - Fossil Fuel Companies	Inventories (Total) - Fossil Fuel Companies	Cash & Equivalents - Fossil Fuel Companies	Long Term Debt - Fossil Fuel Companies	Contribute d Capital - Fossil Fuel Companies	Retained Earnings - Fossil Fuel Companies	Sales (Net) - Fossil Fuel Companies	Net Income (Loss) - Fossil Fuel Companies
2013	N	85	89	88	89	89	89	92	84	89	89
	Mean	33.20272	34190.067	2400.1521	3051.7502	3090.3721	8488.5132	5724.7911	26160.98	40317.654	2816.4189
	Variance	8782.895	2.983E+09	36076014	47904210	27379174	130893987	79054212	3.475E+09	8.092E+09	48955466
	Std. Deviati	93.717103	54616.034	6006.3312	6921.2867	5232.5112	11440.891	8891.2436	58948.714	89956.611	6996.8183
	Minimum	0	1.601	0	0	0	0	0	-3178.454	1.218	-12799.31
	Maximum	706.09	264843	47665.05	35934.342	21688.866	50103.012	46675.726	365125	451235	34770
	Grouped Me	3.748	11442.1	98.727	147.5	474	3369.5	2844.3395	2724.1608	4285	260.001
2014	N	88	89	87	89	89	89	92	84	89	89
	Mean	33.66022	35267.362	2240.7991	2774.875	3244.1165	9080.4093	5938.9794	25730.16	37172.805	2144.9092
	Variance	11233.128	3.025E+09	25335286	37286853	29956238	137157597	86753450	3.404E+09	6.938E+09	27077764
	Std. Deviati	105.98645	54998.801	5033.417	6106.2962	5473.2292	11711.43	9314.1532	58339.913	83292.939	5203.6299
	Minimum	0	1.592	0	0	0	0.325	0	-3857.236	1.108	-5403
	Maximum	858.911	277021.41	36698.883	32125.588	26539.5	54855.463	46691.446	383067	421105	32520
	Grouped Me	3.28025	12846.5	217.4325	141.6315	586	4141.308	3171.4883	3130.9308	4931	538.175
2015	N	87	90	88	89	90	90	93	85	90	90
	Mean	32.92758	33020.409	2030.4329	2225.6401	3165.6196	9416.8512	6148.3699	22402.539	24993.875	-1471.598
	Variance	11235.926	2.774E+09	20517243	21934387	33799391	152939707	96870154	3.119E+09	3.019E+09	22833603
	Std. Deviati	105.99965	52673.242	4529.5963	4683.4162	5813.7244	12366.879	9842.2636	55849.487	54944.983	4778.4519
	Minimum	0	1.586	0	0	0	0	0	-15781.5	0	-23119
	Maximum	852.813	278609.26	31556.784	23168.536	28350	63376.535	61614	389180	266360.18	16150
	Grouped Me	3.275	11510.456	145.40075	153.41	563.311	4652.9618	3289.3835	2479	3137.5	-366.5475
2016	N	87	89	86	87	89	89	92	84	89	89
	Mean	31.67275	31701.494	2075.5702	2084.0069	3027.3877	9766.4896	6571.1159	20436.962	21938.195	-90.14922
	Variance	11058.915	2.75E+09	21217890	19906283	29543209	179141441	97522252	3.139E+09	2.289E+09	7910046.6
	Std. Deviati	105.16138	52442.427	4606.2881	4461.6458	5435.3665	13384.373	9875.3356	56028.584	47841.042	2812.4805
	Minimum	0.002	0.795	0	0	0	0	0	-23821.5	0	-6385
	Maximum	845.799	263044.22	26804.993	20369.697	25441	67920.5	61614	387262.5	233591	15749.592
	Grouped Me	2.705	11911.855	100.07725	153.942	716.129	4670	3686.1563	1355.0358	2627	-243.016
2017	N	87	88	86	86	88	88	91	83	88	88
	Mean	31.00774	32403.836	2217.678	2305.7008	3263.9301	9780.0741	7110.4419	21250.728	27869.632	1707.6372
	Variance	10723.757	2.919E+09	25294188	25471484	32255134	188409000	103712719	3.382E+09	3.743E+09	12411868
	Std. Deviati	103.55557	54025.509	5029.3328	5046.9281	5679.3603	13726.216	10183.944	58158.382	61183.44	3523.0482
	Minimum	0.002	0.002	0	0	0	0	0	-19456.5	0	-5723
	Maximum	826.415	256132.08	26967.772	23499	29063.5	78431	62183.5	391935	309836.62	19710
	Grouped Me	2.789	12401.433	110.573	118.683	786.608	4687.0113	4676.45	1132.0975	3857.787	450.826
2018	N	85	86	85	84	86	86	88	83	86	86
	Mean	31.18155	32885.847	2341.8283	2516.7391	3525.2128	9492.3569	7623.7175	22048.203	32925.172	2437.4849
	Variance	10388.423	2.915E+09	29410558	29306196	40148477	168874015	114225188	3.507E+09	5.402E+09	23429706
	Std. Deviati	101.92361	53988.104	5423.1502	5413.5198	6336.2826	12995.154	10687.618	59223.919	73500.148	4840.4242
	Minimum	0.002	0.002	0	0	0	1.799	0	-17054.5	0	-2669
	Maximum	792.26	254873.18	28340.02	23809.54	30708	70280	62753	400183.5	388379	23352
	Grouped Me	2.573	13477.264	186	121.253	685.84025	4777.2055	4822.5	1388.301	4633.727	586.0215
2019	N	5	5	5	5	5	5	86	5	5	5
	Mean	23.9348	38038.052	403.7036	2383.9387	6804.2626	13192.531	97.14658	25676.52	23955.874	3504.9676
	Variance	151.707	792972546	99393.756	2372485.2	67004213	96908874	216767.52	466988462	383178205	19208260
	Std. Deviati	12.316957	28159.768	315.26775	1540.2874	8185.6101	9844.2305	465.58299	21609.916	19574.938	4382.7229
	Minimum	2.106	5243.327	5.476	75.493	125.017	2132.542	0	1125.798	1693.332	304.274
	Maximum	31.066	67611.5	726.5	3802	15758.5	23618	2928	48506.5	44631	8306
	Grouped Me	28.555	35549.349	391.64075	2540.5754	4831.861	12127.293	47.77789	23468.052	21966.764	304.29
Total	N	524	536	525	529	536	536	634	508	536	536
	Mean	32.19912	33292.708	2200.2558	2494.4731	3250.9855	9371.866	5639.9052	23035.374	30788.192	1265.8801
	Variance	10380.069	2.847E+09	25863094	29933438	32181897	157529121	87619540	3.28E+09	4.864E+09	25885075
	Std. Deviati	101.88262	53360.566	5085.577	5471.1459	5672.909	12551.061	9360.531	57267.291	69741.989	5087.7377
	Minimum	0	0.002	0	0	0	0	0	-23821.5	0	-23119
	Maximum	858.911	278609.26	47665.05	35934.342	30708	78431	62753	400183.5	451235	34770
	Grouped Me	2.96025	12124.473	132.7115	147.5	632.52825	4499.25	2621.226	2314.9043	4162	202.927

Appendix B: Line Charts - Grouped Median of Each Variable from 2013 - 2018

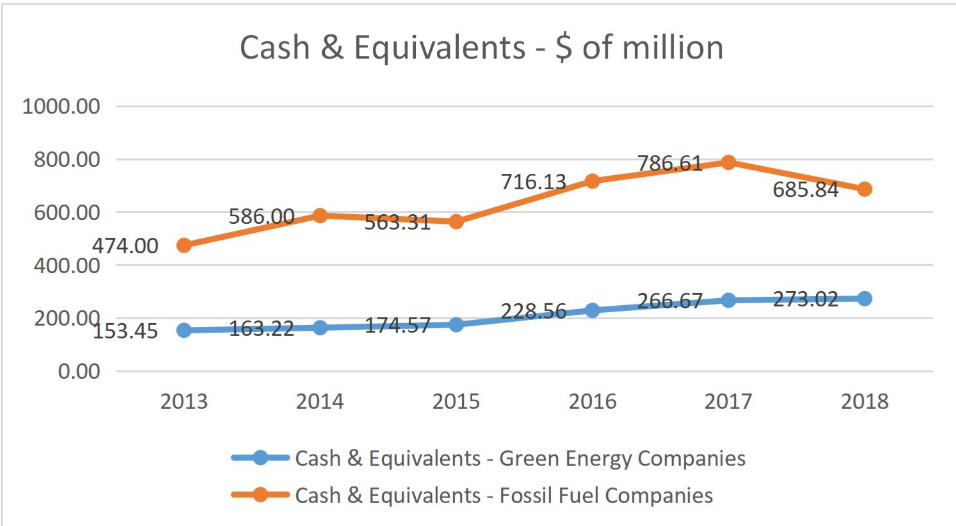




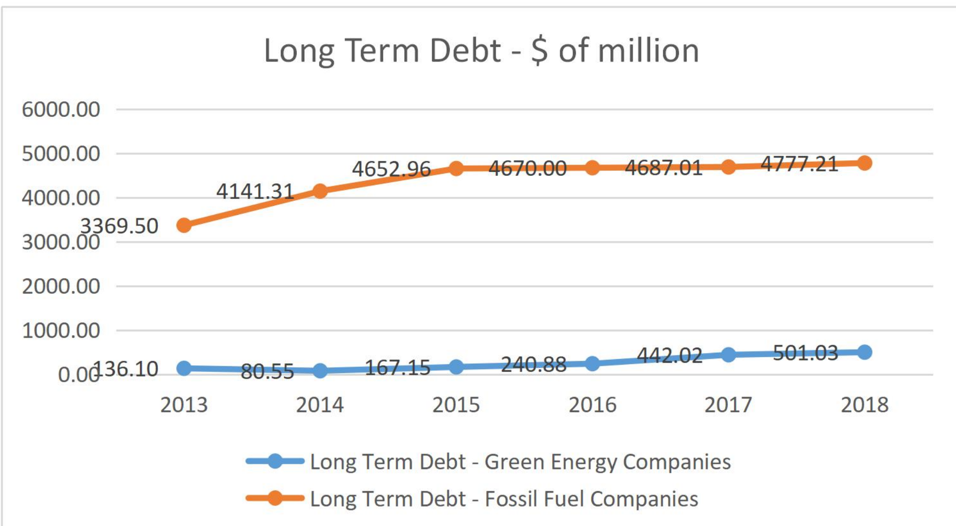




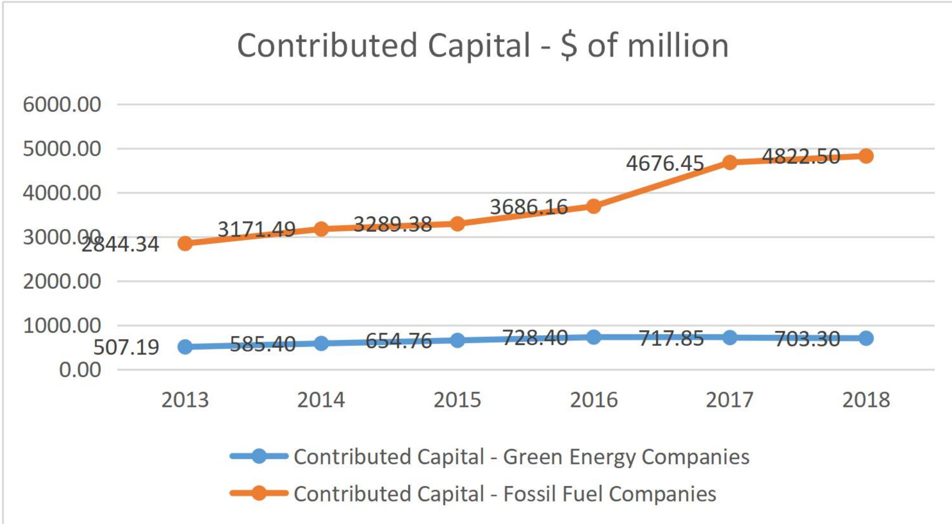
Inventories - $ of million
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
147.50
141.63
153.41
153.94
118.68
121.25
64.28
54.59
60.82
69.29
82.27
103.80
2013
2014
2015
2016
2017
2018
Inventories (Total) - Green Energy Companies
Inventories (Total) - Fossil Fuel Companies

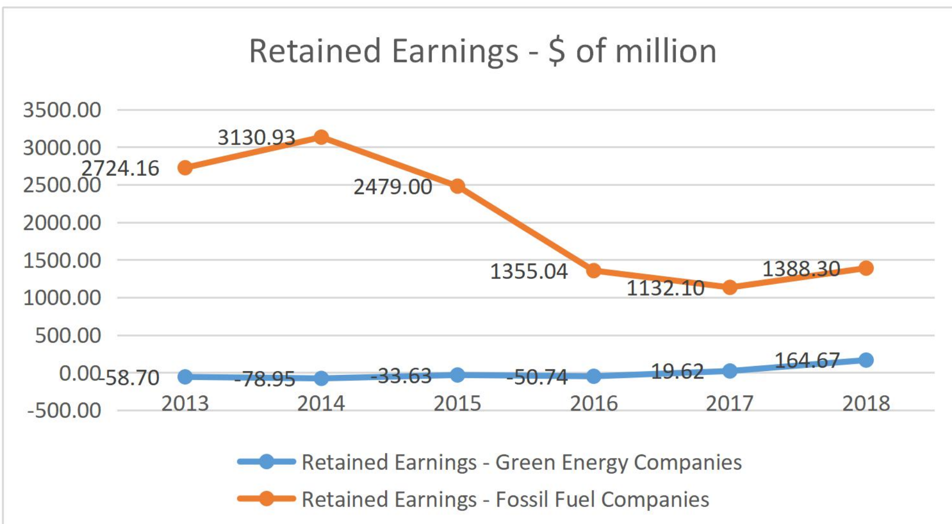


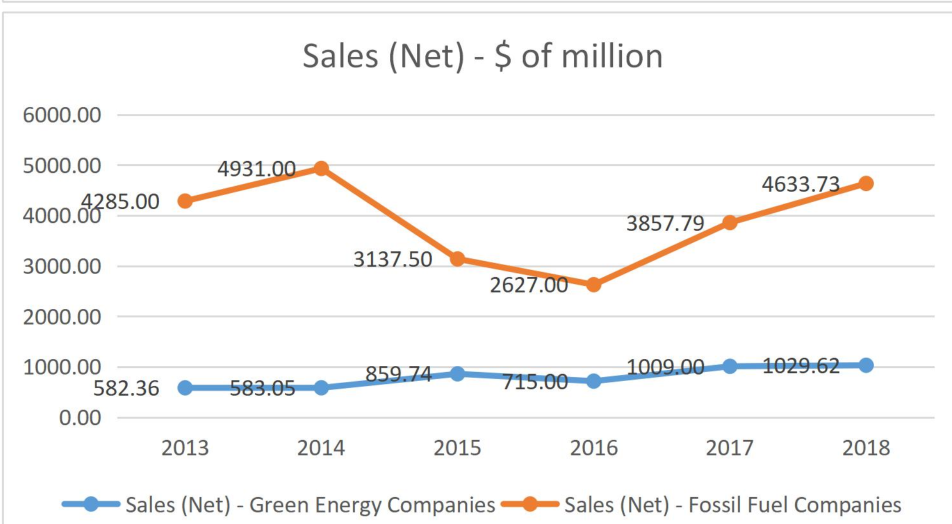
Cash & Equivalents - $ of million
1000.00
800.00
600.00
400.00
200.00
0.00
474.00
586.00
563.31
716.13
786.61
685.84
153.45
163.22
174.57
228.56
266.67
273.02
2013
2014
2015
2016
2017
2018
Cash & Equivalents - Green Energy Companies
Cash & Equivalents - Fossil Fuel Companies

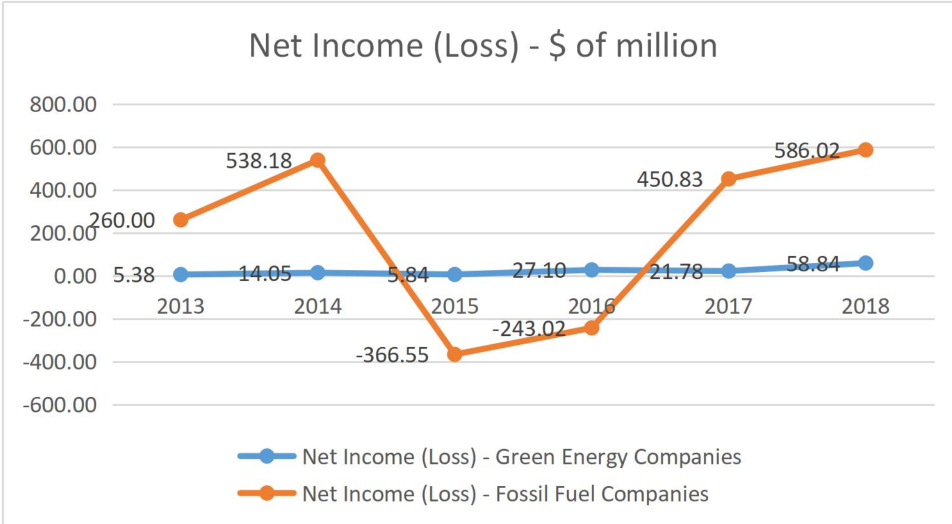


Long Term Debt - $ of million
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
3369.50
4141.31
4652.96
4670.00
4687.01
4777.21
136.10
80.55
167.15
240.88
442.02
501.03
2013
2014
2015
2016
2017
2018
Long Term Debt - Green Energy Companies
Long Term Debt - Fossil Fuel Companies


Contributed Capital - $ of million
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
2844.34
3171.49
3289.38
3686.16
4676.45
4822.50
507.19
585.40
654.76
728.40
717.85
703.30
2013
2014
2015
2016
2017
2018
Contributed Capital - Green Energy Companies
Contributed Capital - Fossil Fuel Companies


Retained Earnings - $ of million
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
2724.16
3130.93
2479.00
1355.04
1132.10
1388.30
-58.70
-78.95
-33.63
-50.74
19.62
164.67
2013
2014
2015
2016
2017
2018
Retained Earnings - Green Energy Companies
Retained Earnings - Fossil Fuel Companies


Sales (Net) - $ of million
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
4285.00
4931.00
3137.50
2627.00
3857.79
4633.73
582.36
583.05
859.74
715.00
1009.00
1029.62
2013
2014
2015
2016
2017
2018
Sales (Net) - Green Energy Companies
Sales (Net) - Fossil Fuel Companies



Net Income (Loss) - $ of million
800.00
600.00
400.00
200.00
0.00
-200.00
-400.00
-600.00
2013
2014
2015
2016
2017
2018
260.00
538.18
-366.55
-243.02
450.83
586.02
5.38
14.05
5.84
27.10
21.78
58.84
Net Income (Loss) - Green Energy Companies
Net Income (Loss) - Fossil Fuel Companies